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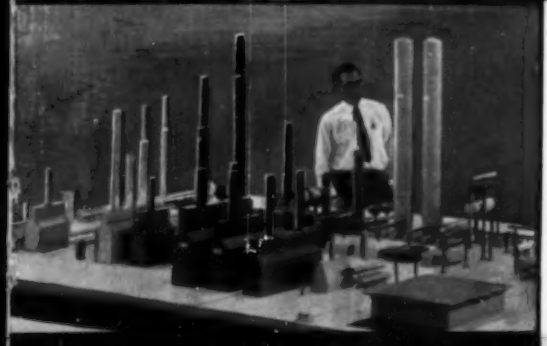
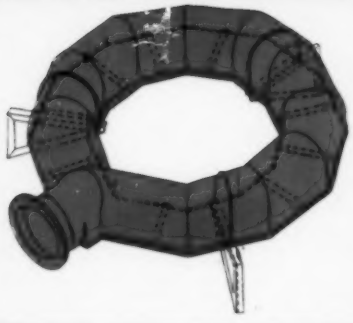
MARCH 1958

CONTROL SYSTEMS ENGINEERING—

Challenge versus Solutions



Models—how to build and use—to develop, prove, and sell your design ideas . . .



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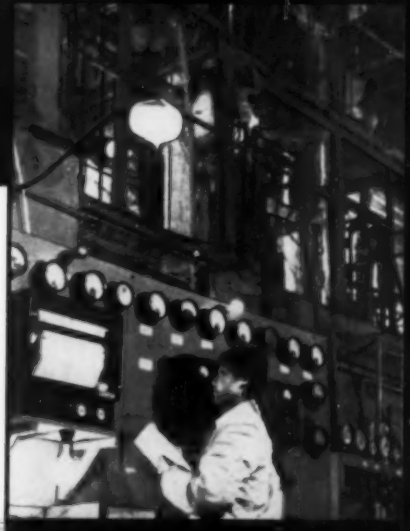

Liquid fuels synthesis—report of long pilot-plant runs

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ON STORAGE

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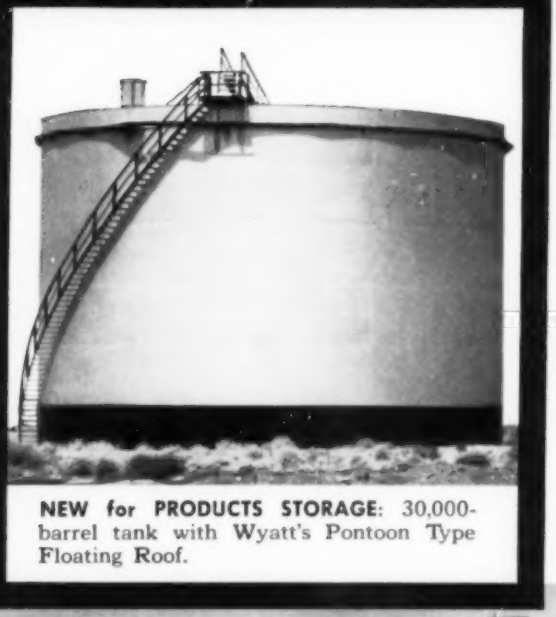
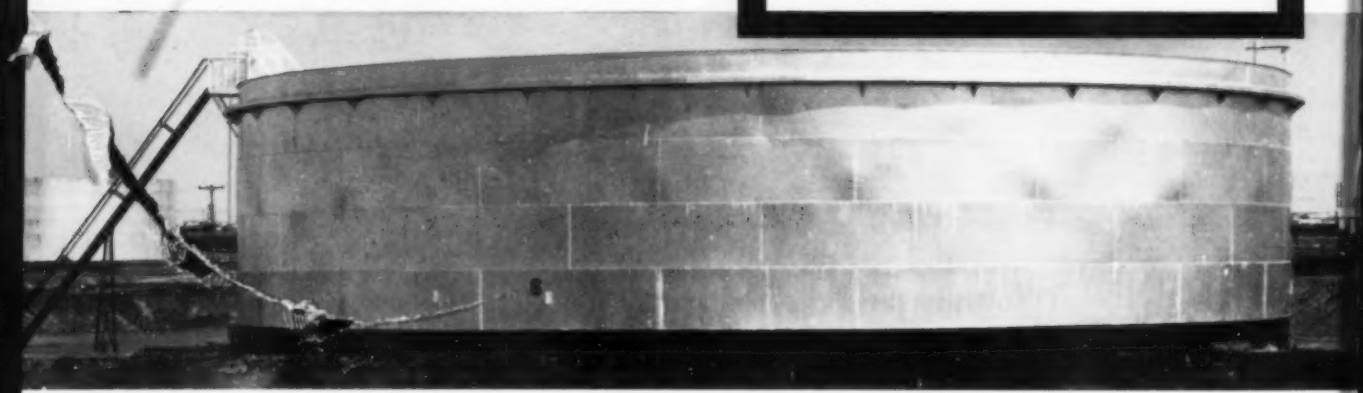
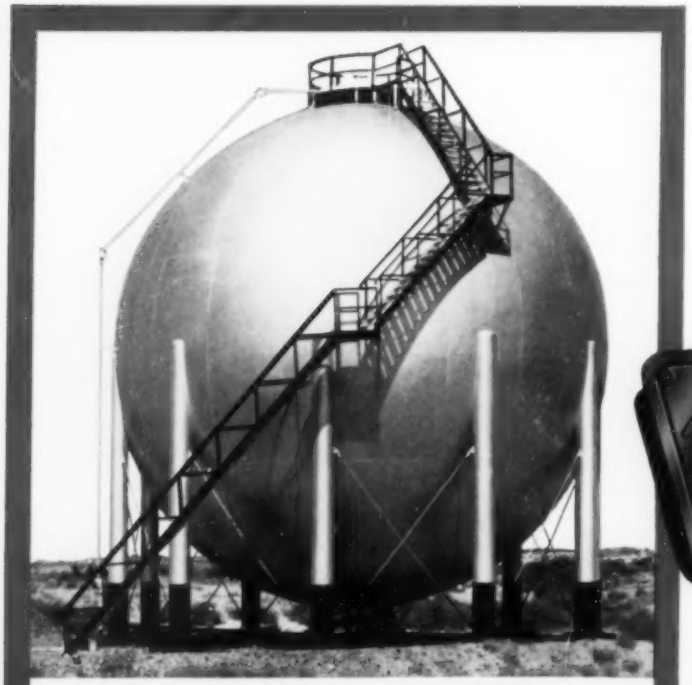
and
THE NEW
add up to
THE MODERN



NEW for PRODUCTS STORAGE: 30,000-barrel tank with Wyatt's Pontoon Type Floating Roof.



CONE ROOF to FLOATING ROOF: After repairs to bottom and shell and addition of a top ring with wind girder, this 55,000-barrel riveted tank was restored to sour crude service — its capacity increased to 58,600 barrels. Wyatt's Pontoon Type Floating Roof reduces Evaporation and Corrosion and prevents Fire.



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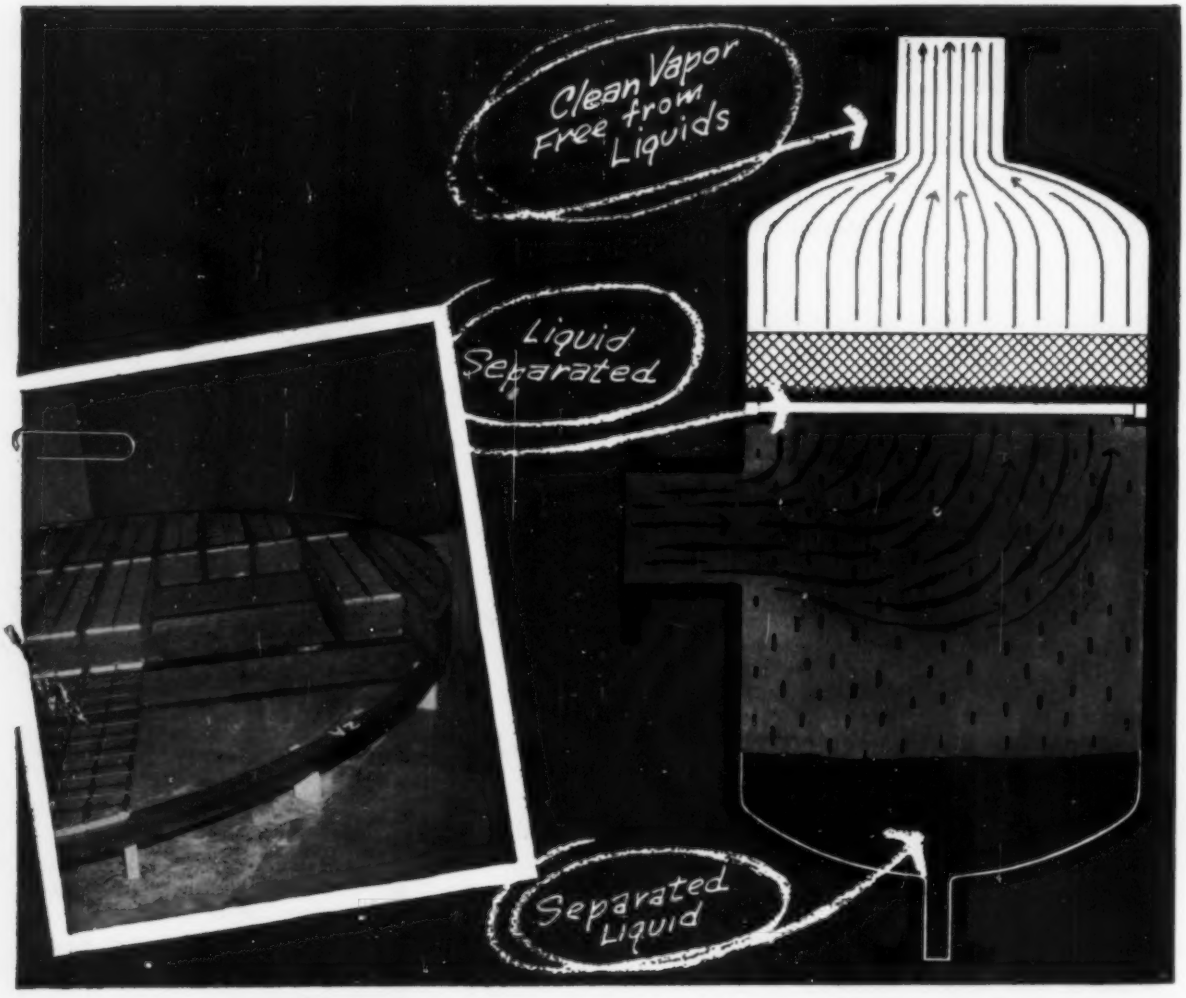

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Cover by Paul Arlt

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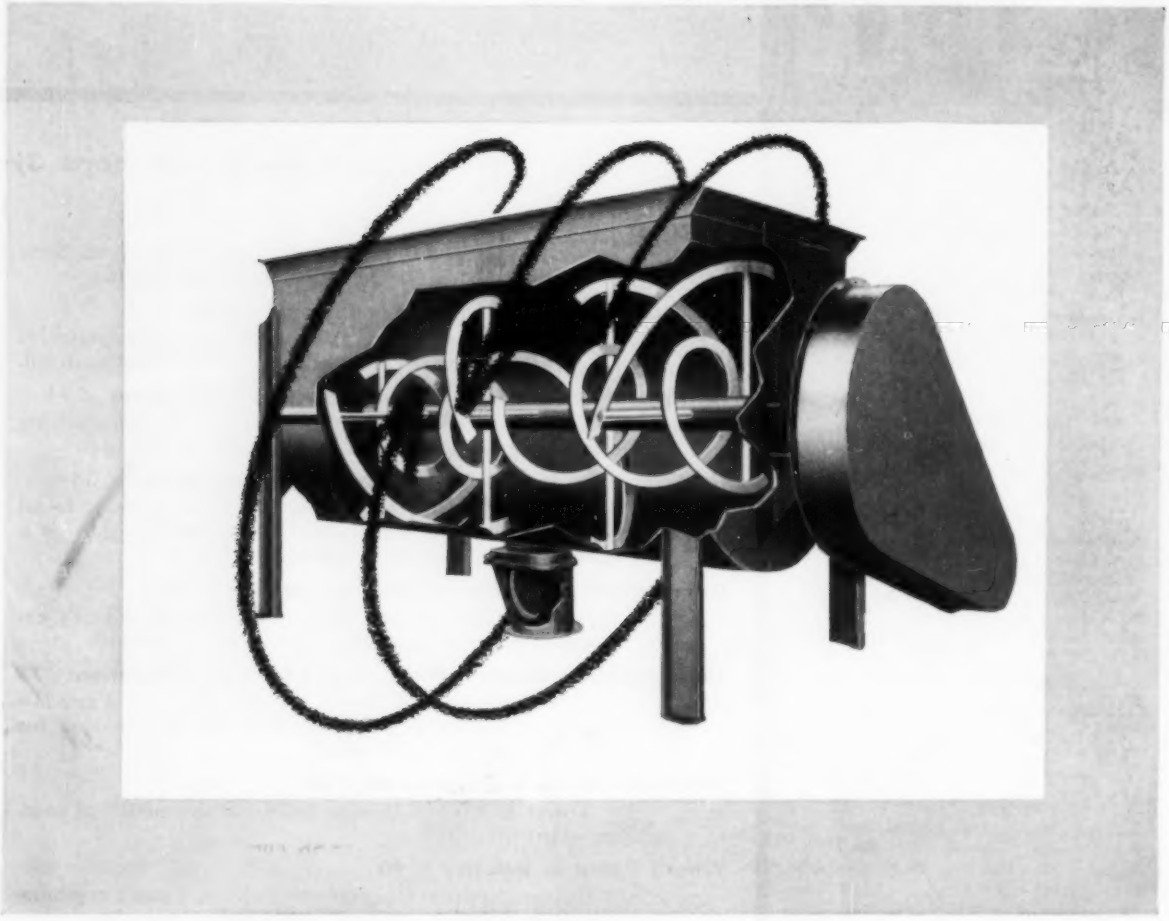

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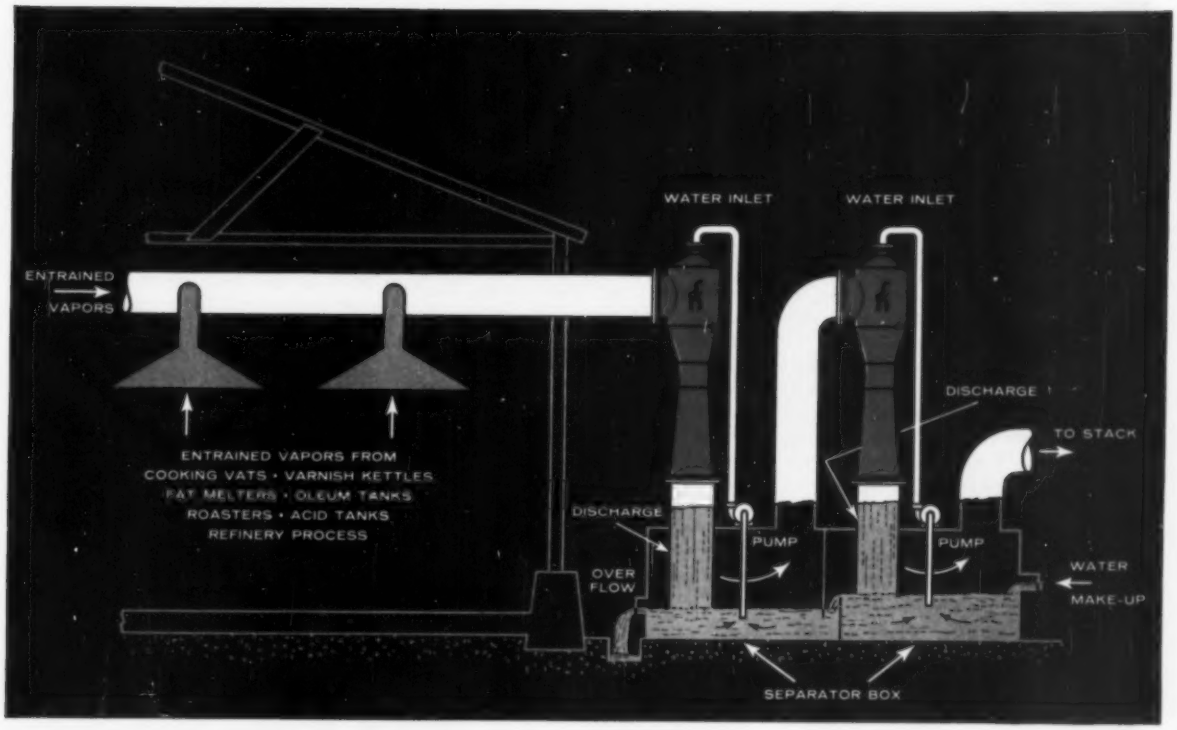

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Photo and sectional drawing of an SK Fig. 4010 Fume Scrubber

A food plant in California uses an SK Fume Scrubber to condense steam and scrub oil vapors from cooking vats. A large chemical manufacturing plant on the eastern seaboard uses a battery of SK Fume Scrubbers to condense steam and purge entrained gas containing H_2SO_4, SO_2, H_2S, TiO_2, and ore dust. A mid-western manufacturer uses SK Fume Scrubbers to vent oleum tanks. A soap maker in Pennsylvania uses a scrubber to remove ammonia fumes from a plant building and cool the building at the same time.

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PRIVILEGED CLASS

Johan Bjorksten | President, Bjorksten Research Laboratories, Inc., Madison, Wisconsin

Here is my reply to your question: "Do you think that educational institutions are becoming too deeply involved in nonfundamental industrial research and development?"

When Scandinavia was still a primitive farming country, it was customary that every farm household should furnish one armed man to the army in case of war. With the advent of cavalry, it was desired to provide an incentive to farmers to incur the extra expense of furnishing horse and cavalry arms. Therefore it was decided that those households who provided a mounted man with horse and equipment should be free from paying any taxes to the government. This freedom from taxes then gradually became hereditary and gave rise to the nobility, the powerful group which for centuries dominated European life and politics.

Our legislators have conferred the same privilege of tax exemption on our educational and nonprofit research institutions. Today taxes are much steeper than in the Middle Ages and the advantage conferred is thus commensurately larger. It seems natural that this new privileged group should take every advantage of this situation and enter not only the field of commercial research, which has been done on an increasing scale, but also every other form of commercial endeavor. The law schools should practice law for the public for compensation; engineering colleges should operate factories, oil fields, and refineries; and business schools, department and chain stores as a part of their educational activities and to strengthen the financial positions of universities.

As these tax-free activities increase in scope, taxes on remaining unprivileged classes of the population will increase in proportion. A shift of power will thus take place; large industry and large unions will be relegated to a dwindling stature. Government, facing diminishing returns, will have to curtail its budget. The power of money will come to rest in the new privileged class of the tax-free universities and foundations.

From our standpoint as scientists or as members of a learned profession, this must be regarded as a favorable development. Certainly, the average intelligence and qualifications in the academic groups are already on a level which compares favorably with any other group. When the logical pursuit of the tax-free activities has brought about a concentration of financial power in the universities, there will be [an] ever-increasing accumulation of the best talents to the tax-free institutions. This may herald an era where . . . the scientists [and other educated groups] will be in reality, if not in name, the ruling group and when reason and sound judgment will prevail.

From the standpoint of those using the commercial research services of tax-free institutions, the immediate key question appears to be whether exclusive assignments of patents from such institutions are valid and will always be held so, or whether or not any taxpayer might claim some share in developments from tax-free institutions. It is to be hoped that legislation will be enacted to make fully clear that the tax-paying public has no share in the commercial inventions made at tax-free institutions, so that this remaining obstacle to the advent of a new privileged class of scientists will be removed.

From *Your Consultant*, January, 1958. Assoc. Consulting Chemists and Chemical Engrs., Inc.

RUNNING SCARED

or, The Advantages of Insecurity

E. P. Partridge * | Hagan Chemicals and Controls, Inc. Pittsburgh, Pa.

As a young engineer goes about prospecting for a job, many interviewers will enquire, "What are you?" What they mean is, "Do you have a degree which leads people to consider you a chemical engineer, or a mechanical engineer, etc."

A much more significant question would be, "What are you trying to become?" This is more important because you will be "becoming" all your life. And today the young engineer will be struggling against a serious handicap in his process of "becoming."

The handicap is not a business recession—all economists graphs point upward for the future. . . . Today, any young engineer can have his choice of at least ten jobs, his *real income* will be slightly more than double mine when I began in 1925. His future will be protected by medical, surgical and hospitalization insurance; unemployment insurance; severance pay; profit-sharing; pension; and social security. He has it made. Why worry about anything?

This is truly a serious handicap. You go farther and have more fun if you run scared. I don't mean a state of panic, I mean a state of mind which keeps you saying, "I should have thought of that," instead of "You didn't tell me to do it."

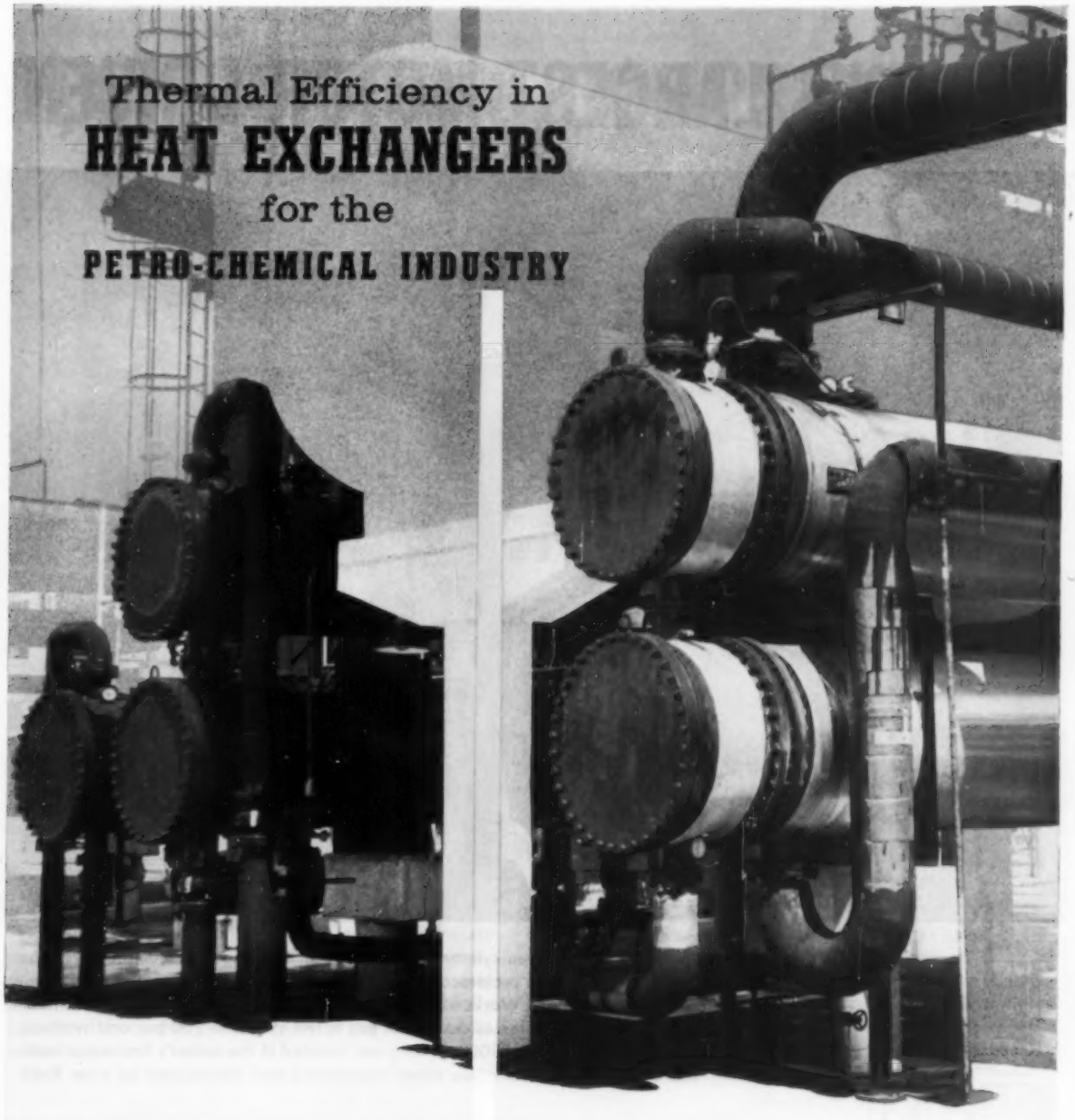
Of course if you accept responsibility you will inevitably feel the weight of it on your mind. You'll worry. You'll feel uncomfortable. Nobody likes to feel uncomfortable. So the majority of men . . . seek security rather than responsibility. Their ideal job is one where everything that goes well is a result of their good work, and everything that goes wrong is the fault of someone else, say an incompetent boss or a dumb assistant. . . .

How much can be expected of an engineer is illustrated by the experience of a man, now retired, who worked for many years for one of the large steel mills in the Pittsburgh area. As a young engineer he was made responsible for all plant water. . . . He discovered to his horror that if one pump taking water from the river went out of service the entire plant operation must inevitably shut down. He convinced his boss, and his boss's boss, all the way up to the president, that a second pump should be purchased. But the president took a long look at the cost and said, "no." Not many months later the pump failed, the mill shut down, and the young engineer was promptly called to the president's office. . . . He pointed out that he had warned . . . had even argued with the president himself . . . could not be blamed for the catastrophe. "Yes," roared the president, "but if we needed that extra pump, it was your job to *convince* me!"

When I stated my thesis that you go farther and have more fun if you run scared, I meant both points.

(*Continued on page* 16)

* In a speech on Student's Night of the Pittsburgh Section, A.I.Ch.E.



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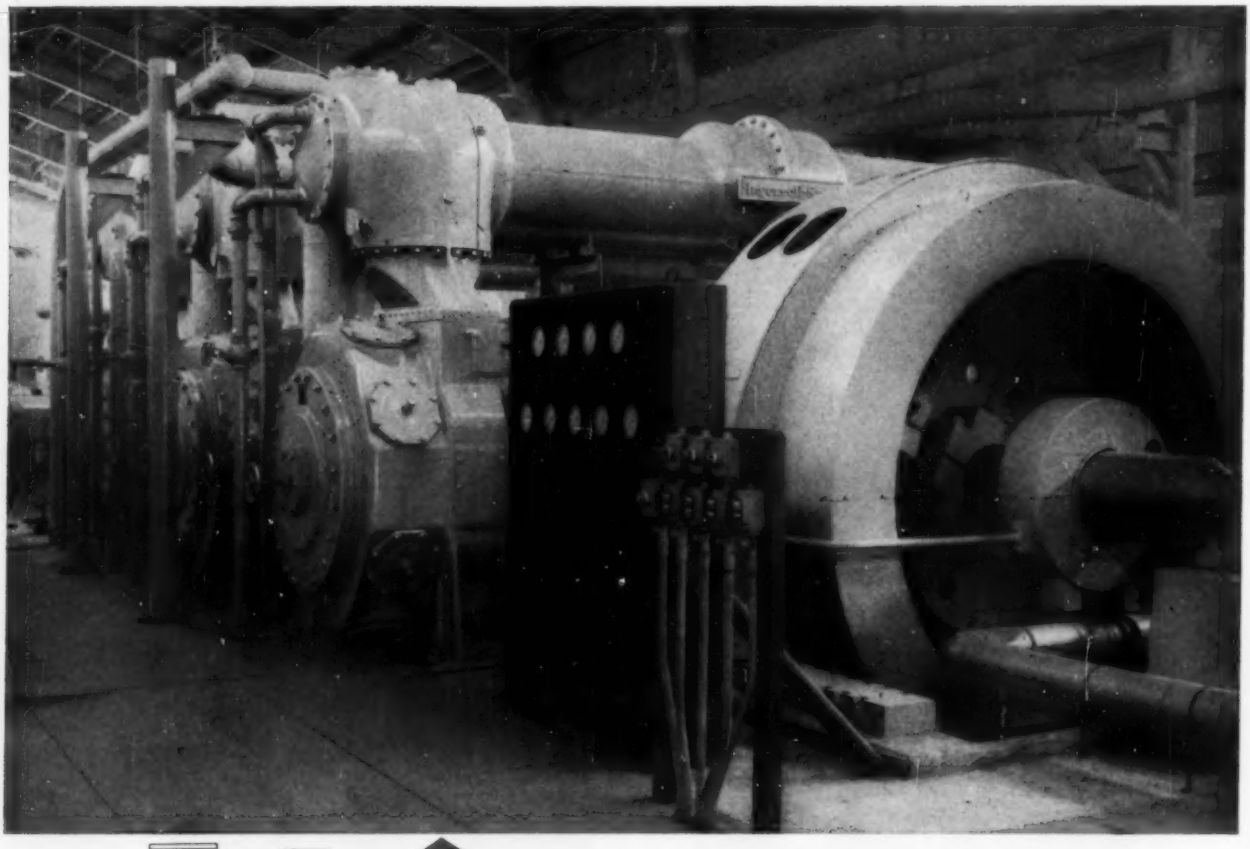
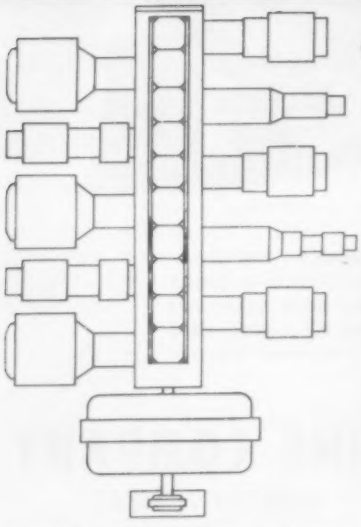
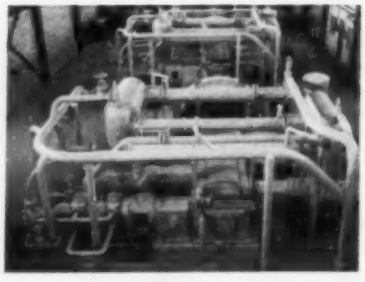


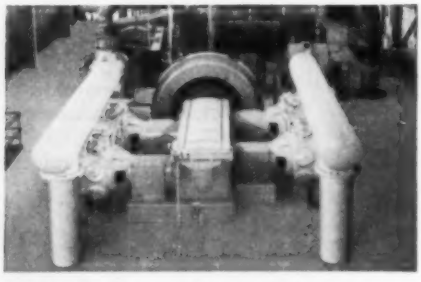
This is one of two ten-cylinder Ingersoll-Rand 6000-hp HHE compressors—the largest motor-driven reciprocating compressors in operation—on ammonia synthesis at the Geneva Works of Columbia-Geneva Steel, Geneva, Utah. Each unit simultaneously compresses coke-oven gas in two stages to 200 psi, and synthesis gas in three stages to 5300 psi. They are installed in the nation's first major steel-mill coke-oven-gas ammonia plant, engineered and constructed by Blaw Knox.



I-R design permits cylinder arrangement for best gas flow; three large cylinders handle coke oven gas in first stage, three in second stage. Others compress synthesis gas in three stages.



Above are two 2000-hp HHE's on air separation service. Each compresses oil-free air to 80 psi, and nitrogen in four stages to 2800 psi. The air cylinders are among the largest non-lubricated cylinders ever built.



This 1750-hp Ingersoll-Rand HHE compressor at the Geneva Works handles fuel gas (coke-oven gas after removal of hydrogen and carbon dioxide) for use in the steel mill. All of these HHE's are installed in the same building.

RECIPROCATING COMPRESSORS

Two 6000-hp Ingersoll-Rand units now in operation at Columbia-Geneva Steel's* NEW NITROGEN PLANT

*Division of U.S. Steel

America's largest electric-driven reciprocating compressors are now at work in America's first steel-mill synthetic ammonia plant. Two ten-cylinder, 6000-hp Ingersoll-Rand HHE compressors—the first units of such size ever put into operation—are at the Geneva Works of U.S. Steel's Columbia-Geneva Steel Division in Geneva, Utah. The plant was engineered and constructed by Blaw Knox Company, and employs almost 20,000 hp of Ingersoll-Rand compressors, both reciprocating and centrifugal.

Big process jobs like this one require heavy-duty compressors that are *engineered* to the job. Compressors of this magnitude are not "off-the-shelf" items. At Ingersoll-Rand, each HHE compressor is carefully engineered from the ground up to fit the needs of its particular job.

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The cylinders must be arranged on the frame in the best sequence, and at the same time the crankshaft is *specially* designed for best running balance, smoothest torque and smoothest gas flow. These Ingersoll-Rand methods of *individual project analysis* have been proven in hundreds of process installations.

The world's most comprehensive compressor experience, in process *and* all other compressor applications, is offered by Ingersoll-Rand. Contact your I-R representative or write now for more information on HHE and other compressors for process services.

This 2800-hp I-R centrifugal compressor handles air for ammonia oxidation. The hot nitrogen from this reaction goes through an I-R expander—a power recovery turbine—which helps to drive the compressor itself.

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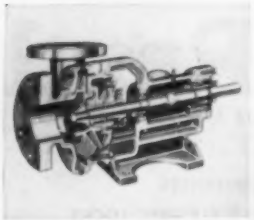

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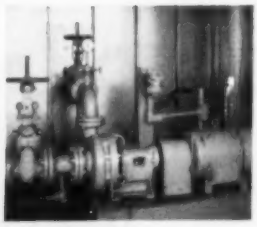

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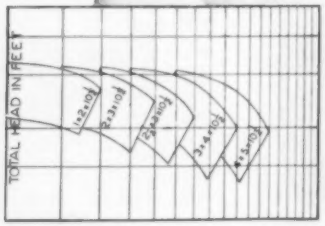

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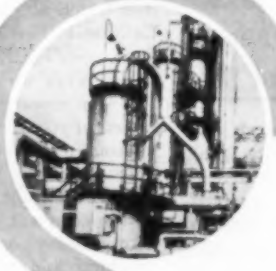

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letters to the editor

Engineering—United

The work [Report of Recognition Committee] by the Engineers Joint Council introduces a subject that I have been giving considerable thought to. It was suggested some time ago that the engineering profession as a whole needs a central governing body which not only does the coordination work which the Engineers Joint Council has been handling very ably but which has authority to act for all engineers. The individual engineering societies should give to the central governing body certain authorities covering the profession of engineering in general, such for example, as setting minimum standards for engineers regardless of the branch of engineering in which they are working. Such an organization could speak with authority on the entire engineering profession, somewhat as the American Medical Association does for the entire medical profession or the Bar Association does for the entire legal profession.

An association of engineering societies could do much more, I believe, than an organization like the Engineers Joint Council to upgrade the status of the engineering profession. The recent article by Barker, (*CEP* November, 1957, p. 19) outlines in an able manner the need for a united engineering organization, and also suggests some of the means by which it might be accomplished.

In addition to the political and legal advantages of having a united organization there are many advantages at the technical level. The publication of material, both technical and industrial, which is of interest to all engineers would provide a central source of such information and would greatly reduce the repetition in publications by the different individual societies. Such a publication would not duplicate any journal now in existence. I think that with proper management it would reduce the total burden on other engineering publications to an extent that would more than justify it.

I am passing these ideas along to you in the hope of adding some weight to the campaign which Mr. Barker is conducting to get an American engineering organization established. I can only repeat that I think this is not only a desirable but an essential step to take, and the sooner general interest in such a project can be developed, the better for all of us.

J. A. Patterson
Pittsburgh, Pennsylvania

Letting the Russians Know

In reading E. L. Piret's interesting account of his visit to Russia (CEP, December, 1957, p. 19) I was struck by his observation concerning the availability of Western technical publications to the Russian scientists compared to an almost complete lack of popular or general-information journals which present a reasonably fair description of the free way of life as we see it. In view of the technological struggle now taking place between Russian and Western science, it would appear to our decided advantage to take advantage of every opportunity to penetrate the curtain of distortion and half-truths or downright ignorance which apparently color the feelings of the Russian scientists in their relations to the West. The free access allowed to technical publications appears to offer an outstanding opportunity to present our side of the picture to the Russian scientists and to counteract propaganda concerning the Western way of life to which they are exposed.

A substantial contribution to a better understanding by the Russians can be made if the various technical journals can seize this opportunity. This might take the form of specific articles concerning advantages of a free economy to the individual which could be included in issues of technical journals known to be used by the Russians. Alternately, it could consist of subtle inclusions in the technical articles themselves, particularly in the background information presented, which need not affect the basic purpose for publishing the articles. For example, a simple picture of an industrial plant with a crowded employee parking lot in the foreground would add little space but much significance to an article on a new process. Articles on new chemicals present the opportunity to compare domestic production with Russian in the course of estimating future demand. Articles on new plants could emphasize the facilities for emlpoyee comfort and tie in the relative mobility of American labor.

Either of these procedures would present the Russians with an uncomfortable decision—either to censor the technical publications, thereby tending to reduce their value to them, and possibly, raising some suspicion in the minds of scientists concerned, or to allow the scientists access to information from which they have been carefully screened in the past. Of the two procedures, the latter would appear relatively more immune to censorship and probably less likely to be disregarded as obvious propaganda.

W. E. Stanley, Jr.
Whiting, Indiana

Let's Retire Frankenstein

Concerning your editorial, "What They Think About Scientists" (*CEP*, January, 1958, p. 39):

Youngsters' gross misinformation on science and scientists comes largely from comics, movies, and "pulp" magazines. When they read the slightly more adult "popular" magazines, this misinformation is only slightly corrected. I know—I'm continually fighting this attitude in the friends of my own children.

The AAS Public Relations Program will achieve mediocre results unless it gets the support of men like Walt Disney and the comic book publishers.

The impact of characters like Disney's "Gyro Gearloose" is terrific on the average youngster. Unless he is guided when very young, such a youngster will always retain a humorous attitude towards these crackpot characters.

A public relations program may help to improve present attitudes—but, if you can get fiction on your side, you'll win the future easily.

Ellis Banfield
Poughkeepsie, New York

Not a Real "Tar"

Concerning mention of the presentation which was made to the Southern California Section of A.I.Ch.E. in June, 1957 (CEP, October, 1957, p. 118): While we are, of course, pleased that our research program was mentioned in your fine publication, a slight misconception crept into either the June presentation itself, or somehow "appeared in the translation." I refer to the comment on page 118: here, a strip mining operation, followed by crushing and retorting, produces 8° API tar very similar to an 8° API oil obtained from nearby wells.

Actually, the gravity of the shale oil produced by our retorting procedure is 18° (to 20°) rather than 8°, and the material is in the gasoline, jet fuel, diesel, and heavier gas oil boiling range, rather than being a "tar."

Union Oil Co. *Fred L. Hartley*
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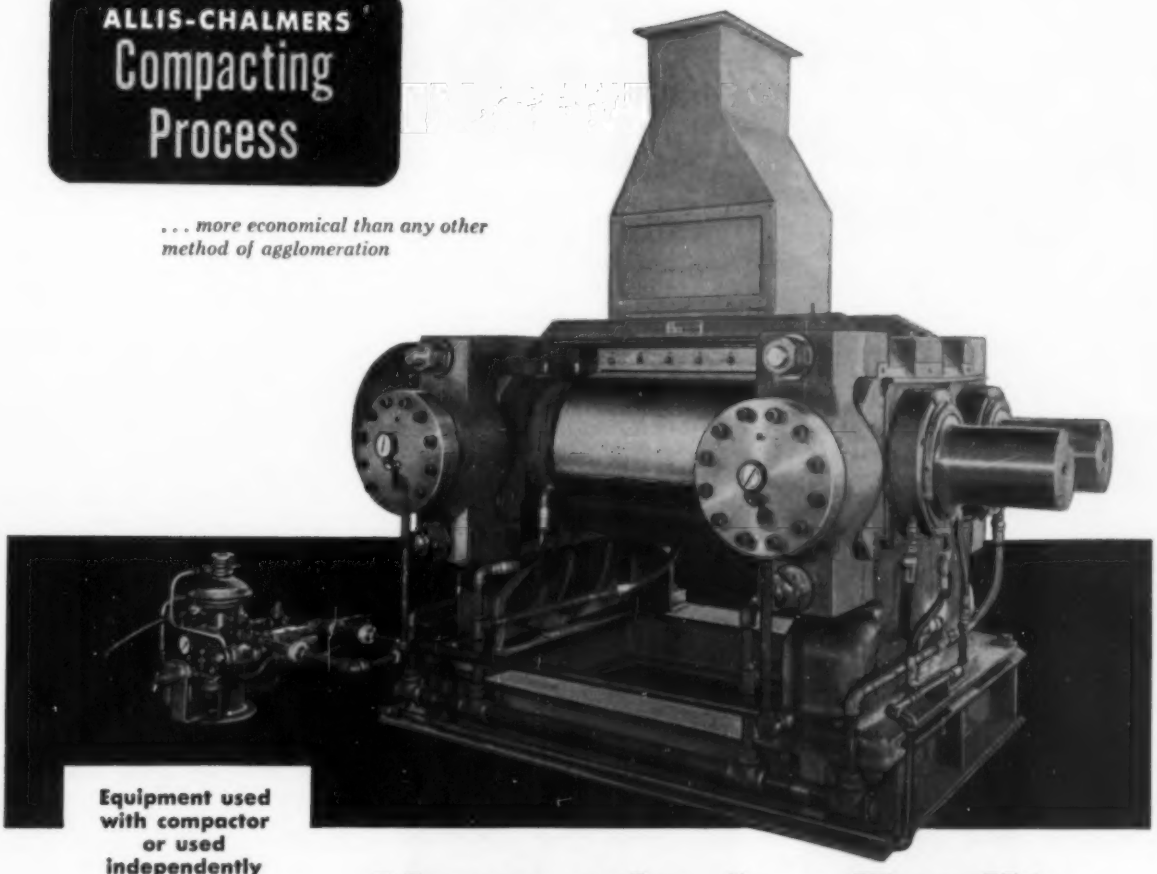
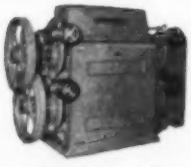


Equipment used with compactor or used independently



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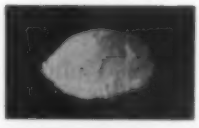

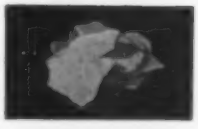

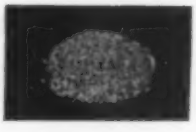

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Letters to the editor

(*Continued from page* 14)

Engineering as a Whole

Here is a course of action which I believe our society should follow at this time:

I hear and read many proposals put forward by government spokesmen, industry spokesmen, and newspaper columnists, containing ideas which will have a long-lasting effect on the careers of engineers. However, along with all other engineering groups, our society is inarticulate. My proposal, therefore, is that our society actively, publicly, and vocally promote the welfare of engineers and engineering.

Following are listed several items toward which, I believe, our program should be aimed:

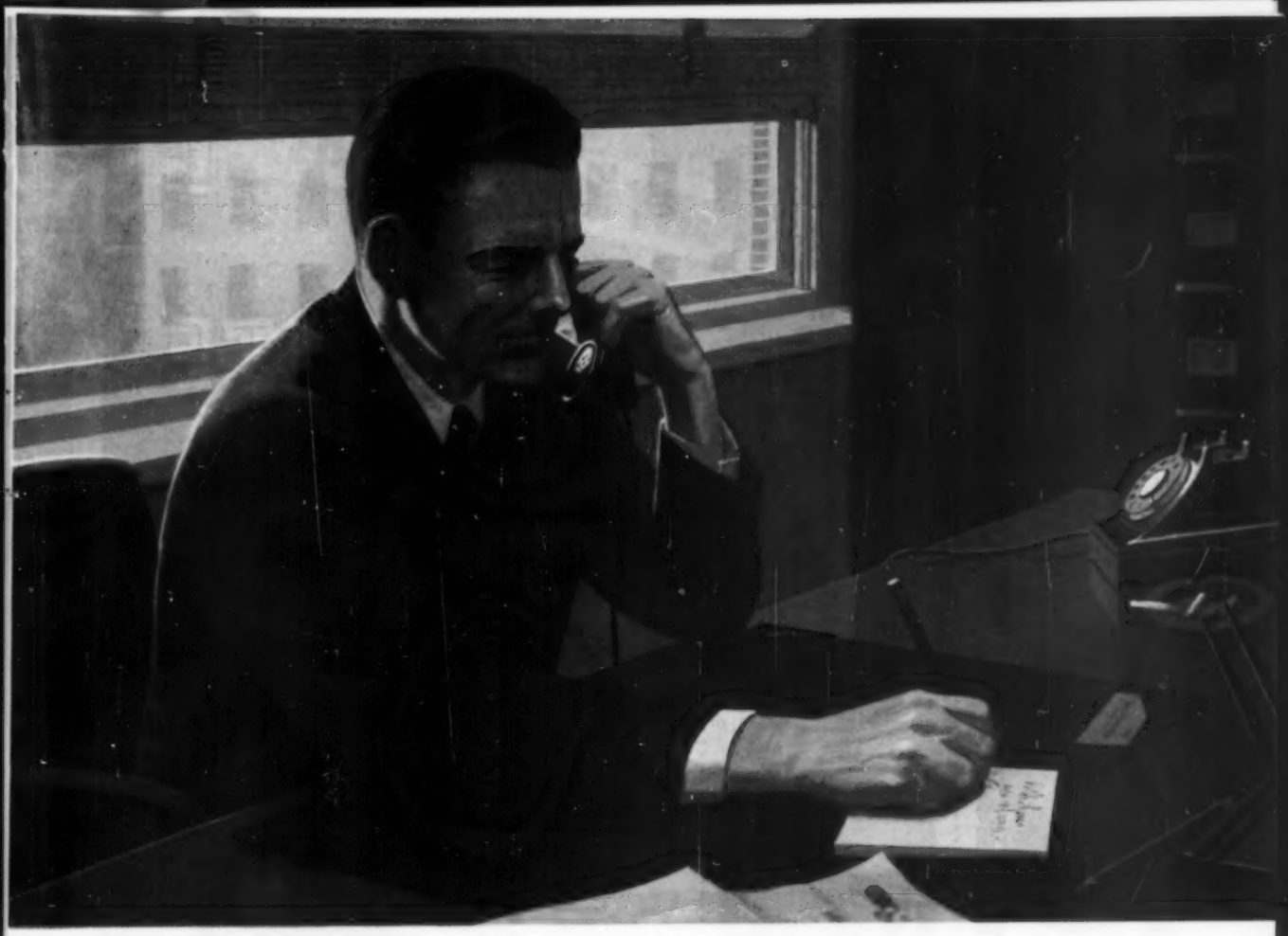
1. Preservation of the engineer's rights as an individual, and maintenance of a free climate for engineering expression.
2. Public recognition of the essential function of the engineer in our society.
3. Utilization of the skills of the existing body of engineers.
4. Maintenance of proper standards for engineering education and society membership.
5. Establishment of engineering as a true profession by creation of a body which can speak for all types of engineers and plan for the advancement of engineering as a whole; and by elimination of the present unnatural dismemberment of engineers into artificial divisions.

John A. Schnelzer
LaVale, Maryland

Noted and quoted

(*Continued from page* 8)

Sometimes an individual who does not have exceptional ability to produce goes ahead of a more able man simply because he is a self-starter who runs scared, while the more able fellow requires so much supervision he is actually less valuable. . . . If you feel personally responsible, you will feel that you really count for something. That is the way most of us human beings need to feel. If you feel responsible, it helps to fix your thoughts on the thing for which you are responsible, which makes for mental health. . . . It has always seemed to me that there is an impressive psychological truth behind the biblical statement that, "He who loses his life shall gain it." I would paraphrase this as: "He who loses himself so completely in living that he identifies himself with what he is trying to accomplish, really lives."



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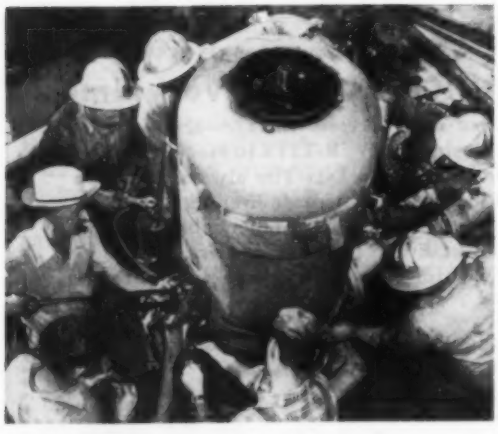

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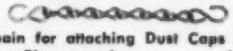

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SCOPE

Inflationary Imbalance Presages Equipment Price Rise

Is the inflation we have lately been hearing so much about, serious? Is it dwindling during the current recession? Will it effect the cost of equipment and process plants this year, next year, five years from now? These and many other questions are on the minds of a great many who are responsible for making decisions relative to outlays of sizeable sums for capital expenditures. Whether to build or wait is a question that is at least partly answered by whether facilities will cost less today, than they would a year from now, or longer.

In an analysis recently presented * it has been shown that with minor exceptions, plant facilities for the process industries have since mid World War II cost more each year than the one past. The question, of course, is whether the same will be true from now on. While no one can be absolutely certain in such matters, the best recourse in such a problem would seem to be to look into past history—which has had its recessions and depressions—for indications which would seem to apply to our future.

In the accompanying chart, it will be seen that, beginning with 1903, there was a period of comparative levelness of the index curves until about World War II, when what is now seen to be the great inflationary rise, got under way. Previous to this change point, variations which in the light of today's curves were comparatively minor, occurred in the inflation of World War I, and the depressions of the early 1920's and 1930's.

Unfortunately omitted from the graph printed with this resumé is a curve representing the index of gross cost of consumed labor hour in the steel industry. Inasmuch as all indexes are adjusted to a 1913 = 100 basis, the labor curve, which like the others started at 100, held fairly constant at about 250-300 from 1924 to 1937-37, when it climbed to 350 and has been climbing ever since. By 1945 it had reached 550, then it levelled slightly in 1948 at 700. The climb became rapid again until 1952, when it had reached 950. By 1954 it was again climbing at a fast pace, reaching 1350

(*Continued on page 21*)

* Based on an address by Frank G. Breyer, partner and chairman of Singmaster & Breyer, Engineer-Constructors, New York, N.Y. before the Chemical Equipment Sales Engineers Association of N.Y.

F, B & D Offers Stengel NH_4NO_3 Process

Ford, Bacon & Davis, Inc., N. Y. engineering firm, has a world-wide license agreement with Commercial Solvents covering the design and construction of facilities for the manufacture of ammonium nitrate by the Stengel process. F, B & D will provide complete units having capacities to 350 tons/day.

American Potash-Lindsey to Merge

American Potash & Chemical Corp. will merge with Lindsay Chemical Co., if shareholders of each firm vote approval at meetings to be held April 29th. Under the agreement, Lindsay would be operated as Lindsay Chemical Div. of American Potash. American Potash, through its plants in Trona, Los Angeles, and Henderson (Nevada) has a strong position in boron compounds, lithium, rubidium & cesium chemicals, etc. and is expanding its activity in rockets and missiles. Lindsay is a leading producer of thorium, cesium and rare earth chemicals at its Chicago plant.

Socony-Mobil's $28 Million Expansion

Socony Mobil Oil Co., Inc. has announced plans for the construction of a $28 million oil refinery to be built in Venezuela. Specific location will be at El Palito, about eight miles west of the terminus of the Barinas-El Palito crude oil pipeline—which was completed last November. Construction will be by Socony Mobil de Venezuela, a wholly owned affiliate. Construction is to begin soon, with completion in 1959. Initial capacity will be 40,000 bbl./day. Some of the lighter products will be marketed in Venezuela, the remainder going into world markets. Shipments to the U.S. are not contemplated.

Hooker, Foote Form New Solid-Fuels Firm

A new firm to be known as HEF, Inc. has been announced by Hooker Electrochemical and Foote Mineral. HEF will specialize in the manufacture of components of solid fuels for rockets, including ammonium perchlorate and other perchlorates—which Hooker already produces. The joint venture is termed a bid for the larger market expected to develop.

SCOPE

Who Will Administer 'Space' Development?

Nation's Capitol 'Up In Air' Over Problem . . .

Whoever controls space will control the world . . . but of more immediate importance to chemical engineers is that whoever manages the efforts of the U.S. to control space, will also control a lot of research and development contracts and contracts for billions of dollars worth of chemical fuels and chemical equipment.

It is for administrative control over the projects which will ultimately enable man to accomplish the conquest of space, that various elements of the Federal government are now vying. It is a prize worthy of great effort. By comparison the atomic energy program is pip-squeak.

The all important question of who shall control the space projects is being asked of top-drawer executives of the missile industries by the Association of Missile and Rocket Industries (AMRI). Executive director K. D. Hoyt reports that while his survey is far from complete, there are about 200 answers which already indicate: *Almost all respondents are in favor of more centralization of authority; almost none feel that changes in the Dept. of Defense will suffice; Answers are about equally divided on whether control should be placed under a Space Czar or an independent agency; About 60 per cent prefer a new agency, rather than to have the program under the National Advisory Committee for Aeronautics (NACA).*

NACA seems to want the assignment as space control agency, for they have just formed a "Space Technology Committee" made up of such notables as Pickering of Jet Propulsion Laboratory, and Von Braun of Army Ballistic Missile Agency. NACA is an independent agency created by act of Congress, and it acts on request of the President, Congress, or any executive agency. With such experience as with the X-15 rocketship program, designed to explore to a 100 mile altitude, NACA evidently feels that its 43 years of service is prima facie evidence of its ability to do this job.

The AEC, because of its interest in the nuclear rocket engine program, has been mentioned as an agency that might conceivably get the space program.

The National Science Foundation, created in 1950 to "promote the progress of science; advance the national health, prosperity, and welfare; and secure the national defense," has been mentioned and certainly could justify, legally, the right to accept the assignment as space control agency.

Early in February, the $1.26 billion emergency defense bill put the Advanced Research Project Agency (ARPA) under secretary of defense McElroy, in business. G-E's Roy W. Johnson, who has been appointed to head it, is said to be quietly organizing a staff under a $1.4 million budget.

Other proposals include establishing a Department of Science and Technology headed by a cabinet member, and a National Science Council comprising five members to be appointed by the President.

President Eisenhower's Science Advisory Committee headed by special assistant James R. Killian, Jr., is now assisted by a staff of five technologists, including a chemical engineer. This Committee has divided its consideration of the space-science program into two parts: (*a*) *definition of the problem, and* (*b*) *recommending the type of organization best suited to have cognizance of space problems.* There are 14 panels concurrently considering these two phases of the program.

On February 6th, Senate Res. 256 was agreed to, which created a special Senate committee "authorized and directed to conduct a thorough and complete study and investigation with re-

(*Continued on page* 22)

Senate Committee Acts on Science Dept.

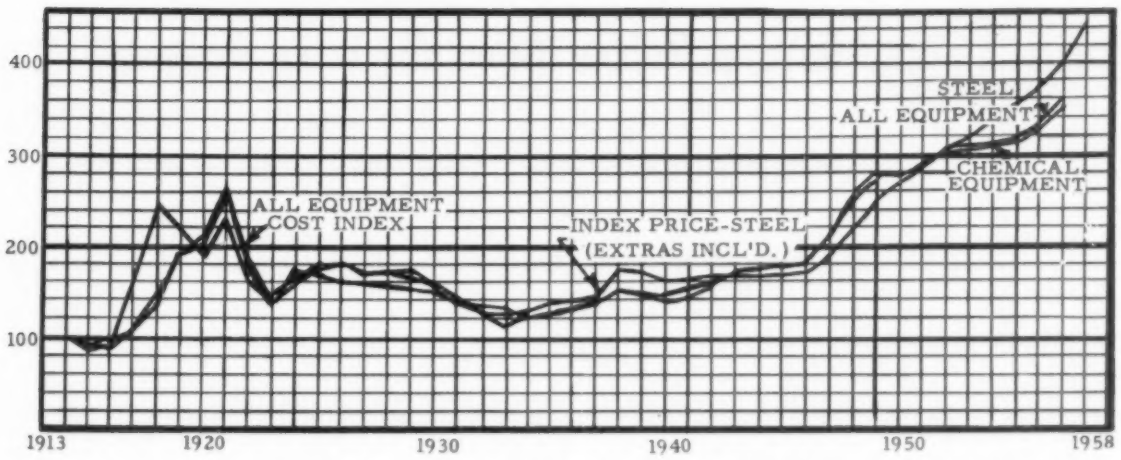
An important Washington move which bears watching occurred recently when the staff of the Senate Committee on Government Operations issued a Staff Memorandum (No. 85-1-73) on "Reorganization of Federal Science Activities." Its tentative exploratory plan would place within a Department of Science and Technology the National Science Foundation, Smithsonian Institution, Bureau of Standards, Office of Technical Services (Commerce), Boulder Labs. (Commerce), Patent Office, Weather Bureau, and others.

Relaxation Seen on ROTC Duty Policy

What may mean yielding to long pressure by professional groups are the recently announced policy changes in the duty assignment of Army and Navy ROTC graduates. About 100 Navy ROTC'ers will go to labs for initial tour of duty. Army will give priority to engineering ROTC grads for a six-month (short term) ROTC duty tour.

Pending Govt. Pay Raises Protested by NSPE

Congress is understood to be considering Government pay raise legislation which would deny full classified pay increases to those scientists and engineers who were raised to the top step of their grade under a recent Civil Service Commission order. In telegrams to Senate Majority Leader Lyndon B. Johnson and chairman of the House Post Office and Civil Service Committee Tom Murray, the National Society of Professional Engineers has protested the terms of such legislation. NSPE wants Federal scientists and engineers to retain their present classifications at the top step of their grades, and at the same time be afforded the full benefit of any classified pay raises approved by Congress. In recent testimony before the House Committee on Post Office and Civil Service, NSPE representatives pointed out that "the action we favor, which is designed to permit the Federal Government to raise the salary level of its engineers and scientists more in line with comparable salaries offered in industry, has been endorsed in principle by the Cordiner Committee and the Committee on Scientists and Engineers for Federal Government Programs."



COST INDEX OF CHEMICAL PROCESS EQUIPMENT . . . 1913 = 100

INFLATION—*continued from p.* 19

by 1958, and showing no signs yet of slacking-off. This means that the labor for producing steel is costing today about 13½ times what it cost in 1913.

At the same time, it will be seen from the accompanying graph that the price of steel has climbed to an index of 450, or 4½ times the 1913 price. The difference in indices is explained as based on several factors, including increased efficiency in use of manpower in the industry through automatic control and improved processes, etc.

Of great significance to the chemical engineer is the index curve for chemical plant equipment, which is currently lagging behind the steel index curve, but (historically) is seen to be once again catching up—as it always has in the past.

For the three years following 1950, the curve for chemical plant equipment advanced little. Then in 1954 it began to rise, increasing its rate in 1955 and 1956. The five year lag may impell it to rise even faster.

As to the general inflation, the analysis based on the curves gives no indication as to how long it may last, or what its ultimate disposition will be. A force which has been primarily responsible for bringing inflation into being—and seems destined to perpetuate it—includes the support now seen to be given by both political parties to an ever-upward spiral of wage levels. That the rise in prices of manufactured goods seems to lag by about ten years the rise in labor costs, is attributed in the analysis to several factors. Among these are the results of managements' efforts to offset added labor costs through labor-saving devices and improved processes. Another factor is that only part of the cost of the labor going into a product is direct labor. The other part is that which had to do with the cost of the plant in which the product is made.

Which brings one back to the original premise: Will the process plant built next year, or five years from now, cost more than it would today? What do you think?

Nixon Asks Civil Control of Science

In a recent address before a California Institute of Technology faculty and student audience, Vice-President Richard M. Nixon said that civilian, rather than the military, should have administrative control in scientific developments, particularly those dealing with outer space. He also called for a shift of emphasis from war to peace as an objective of scientific endeavor, and asked that scientists be given all the freedom they need to explore the unknown. Prior to the address, he told a news conference: "We cannot tie down our scientists to the specific objectives which military men or political leaders deem possible or desirable. The greatest advances for mankind have been made . . . when they (scientists) had, in effect, complete freedom in basic research to explore the unknown.

Spevak Wins Supreme Court Test

Jerome S. Spevak, the inventor of a heavy water production process, who has sued to restrain the Atomic Energy Commission from revealing the details of his invention until he could file patent applications in foreign countries, received good news from the Supreme Court on March 4th. On that date that Court told the United States Court of Appeals in Washington, D.C. to try the inventor's case. Earlier, the Appeals court had ruled against him, on the basis that his suit was against the United States, which could not be sued without its consent. For other details, see SCOPE, *CEP*, Feb. '58.

ASEE Offers 4-Point Program to Killian

The American Society for Engineering Education has presented to James R. Killian, Jr., President Eisenhower's special assistant for Science and Technology, a four-point program to encourage more engineering students to enter graduate study. The plan calls for a substantial increase in the number of NSF fellowships, a program of secondary grants to those failing to qualify for full NSF aid, supplementary Federal grants to NSF fellows who take on part-time teaching, and special awards under NSF to aid graduate students who take on teaching duties.

SCOPE

Natural Rubber Stockpile to be Reduced?

New 'Synthetic-Natural' Freeing Nation From Dependency

The five-year natural rubber stockpile base may soon be reduced to a three-year base, if the recommendations of the special stockpile advisory committee of the Office of Defense Mobilization are accepted and carried out. This is the substance of an important announcement made before the recent Washington (D.C.) Rubber Group Decennial Meeting, by H. E. Humphreys, Jr., chairman and chief executive officer of The United States Rubber Co.

Said Humphreys: "With our present large capacity to produce synthetic rubber and with the new isoprene type of synthetic rubber that closely simulates natural, we could get along nicely with no natural rubber if we ever needed to. Thus, I am pleased to learn of (the recommendation by the committee). Certainly, this is more realistic than the five-year supply we have been maintaining. . . . However, the industry and the government must consider the best procedure to use in reducing the stockpile. A sudden dumping of stockpile rubber onto the market would depress prices . . . An orderly program should be developed to release rubber from the stockpile when demand is in excess of supply. Some industry leaders believe this situation will occur by 1960 . . ."

Space—*continued from p. 20*

spect to all aspects and problems relating to the exploration of outer space and the control, development, and use of astronautical resources, personnel, equipment, and facilities. All bills and resolutions introduced into the Senate, and all bills and resolutions from the House of Representatives, proposing legislation in the field of astronautics and space exploration shall be referred, and if necessary re-referred, to the special committee."

The committee is made up of the following members: *Chairman,* Lyndon Johnson. *Democrats:* R. B. Russell, T. Green, W. Magnuson, J. L. McClellan, C. P. Anderson, S. Symington. *Republicans:* S. Bridges, A. Wiley, L. Saltenstall, J. W. Bricker, K. E. Mundt, B. B. Hickenlooper.

The committee is required to report to the Senate by June 1, 1958 or the earliest date thereafter, but not later than January 31, 1959.

After visiting various government offices, one quickly concludes there is no lack of imagination. There is a great feeling of urgency. The enormity of the job is almost beyond human comprehension. The cost may be as great.

While some commercial uses will evolve from the space programs, the whole cost must be borne by taxes. This heavy cost in dollars will be converted into the employment of many men and the procurement of vast quantities of materials. This will mean great new career opportunities for scientists and engineers and much profitable business for materials producers and missile makers. It also means that every taxpayer will have to dig to provide the money to foot the bill.

J. L. Gillman, Jr.

AEC to Promote Radioisotope Use

The AEC is embarking on an aggressive campaign to increase the industrial use of radioactive materials. First step is to request $5 million for the program in its budget for the fiscal year beginning July 1st. Program calls for development of an experimental isotope production reactor at ORNL, with research on cheaper packaging and distribution methods; increased training of industrial personnel on how to handle and use radioisotopes; and a broadened effort by the AEC, in cooperation with industry, to demonstrate new and exploit known, industrial uses.

Soviet May Try to Curb U.S. Translations

Recently, the Soviet Union announced a special arrangement with a private U.S. firm engaged in translation activities, whereby the firm (Consultants Bureau, Inc.) would be provided with advance copy material, original photographs, etc. to expedite its issuance of the translations in this country. In exchange for this privilege, covering twenty Soviet scientific journals, the firm has agreed to make royalty payments to the Soviet Government. Now, it is reported that Soviet spokesmen here have said it is the intention of their government to adhere this year to the Geneva Universal Copyright Convention. Such action by the Soviet Government would give it legal property rights to Soviet material reaching this country so that Soviet permission would be required for the publication or translation.

Engineering Enrollment at New High

Total engineering enrollment has reached the highest level in our country, according to the U.S. Office of Education—on the basis of a survey made jointly with ASEE. The total is now 297,000—an increase of 7.2 per cent over last year. This compares with an increase of 4.1 per cent for all college enrollment. Engineering freshmen enrollment is 78,757—second highest in our history, and 1.3 per cent above last year. This compares with 0.9 per cent increase for all college first-time students. Engineering bachelors degrees awarded in the U.S. increased in 1956-57 18.6 per cent over the year before. Masters rose 10.8 per cent. The number of doctorates, however, declined 2.3 per cent! Comparable final data for all college degrees are not yet available, but it is estimated that all bachelors degrees rose 6.8, masters 14.8 and doctorates 2.3 per cent.

ADVERTISEMENT—*This entire page is a paid advertisement* *Prepared by U. S. Industrial Chemicals Co.*

U.S.I. CHEMICAL NEWS

March ★ A Series for Chemists and Executives of the Solvents and Chemical Consuming Industries ★ 1958

Polyethylene-Brass Bonds Possible with New Adhesive

A new adhesive developed by Bell Telephone Laboratories and reportedly able to resist a pull of 1,000 psi is being used to bond polyethylene directly to brass, brass-plated metals, and rubber. It is based on a compound described as partly hydrogenated polybutadiene, which is vulcanized by the addition of other materials. Any degree of unsaturation of the polybutadiene from 3-30% is reported to provide excellent adhesive action.

Temperatures from 250-350 F and pressures of 100 psi or less are required for bonding. A layer of the adhesive 2 or 3 mils thick is desirable. This layer can be brushed or sprayed on, or inserted between the materials to be bonded as a thin, prefabricated sheet.

Possible uses include bonding of polyethylene to brass in submarine cable amplifiers for underwater phone cables, linings for tanks and plating racks.

Sandwich of brass, polyethylene and rubber shown here is held together by new adhesive. It can support about 2,000 pounds.

ISOSEBACIC® Acid Synthesis To Be Described At April ACS Meeting

A paper on U.S.I.'s new dibasic acid synthesis is to be presented at the symposium on alkali metals, being held at the 133rd national ACS meeting in San Francisco, April 13-18.

The process described in the paper was developed for use in the company's new ISOSEBACIC® Acid plant which is soon to go on stream. In this synthesis, butadiene is reacted with very finely dispersed sodium to form disodiooctadiene — an organometallic compound. Carbonation, hydrogenation and acidification then yield three major products — sebacic acid, 2-ethylsuberic acid and 2,5-diethyladipic acid. The mixture of the three has been trade named ISOSEBACIC Acid by U.S.I. and is finding application as a vinyl plasticizer and as an intermediate for many plastic applications. Until the development of this synthesis, 2-ethylsuberic and 2,5-diethyl-

MORE

National Petro-Chemicals Corp. Becomes a Wholly-Owned Subsidiary of National Distillers

Giant Tuscola, Illinois Plant Continues Under U.S.I. Management

Panhandle Eastern Pipe Line Company's 40% minority interest in National Petro-Chemicals Corporation has been transferred to National Distillers, which thus becomes sole owner. Panhandle has acquired 1,500,000 shares of National Distillers common stock in exchange.

National Petro owns and operates a large integrated petro-chemicals plant at Tuscola, Illinois. U.S.I. Division of National Distillers will be responsible for management of this chemical complex as it has been in the past.

Expansion of National Petro beyond the original plan was one factor that led to the transaction. As originally conceived, Petro's basic raw materials were hydrocarbons extracted from Panhandle's natural gas pipeline at Tuscola. However, the company's new polyethylene plant at Houston will use ethylene purchased from another source.

Nixon Named Petro Vice President

John W. Nixon has been elected Vice President of National Petro, and manager of all National Distillers operations at Tuscola, including the Petro and U.S.I. facilities. Dr. Robert E. Hulse, National Distillers Executive Vice President, was named National Petro Executive Vice President, and Robert Cornwell, U.S.I. Vice President in Charge of Production, has also been named a Petro Vice President.

Since 1951, Petro has been producing ethylene, ethyl alcohol, ethyl chloride, ethyl ether, LPG and later polyethylene at Tuscola. It supplies hydrogen to U.S.I.'s ammonia production facilities. Petro also has the facilities to manufacture other related bulk chemicals on long term contract basis if the demand arises.

Panoramic view of a portion of the National Petro-Chemicals Corporation plant. Ethyl chloride, ethyl ether and ethyl alcohol production and storage facilities are visible in the background.

Attention: Users of Taxpaid Alcohol for Nonbeverage Purposes

The Alcohol and Tobacco Division of Internal Revenue has recently issued Industry Circular No. 57-37 covering the filing of nonbeverage drawback claims on taxpaid alcohol by manufacturers of nonbeverage products. This circular suggests that such claims be delivered personally to the office of the assistant regional commissioner (alcohol and tobacco tax), or sent by registered or certified mail, with postmarked receipt.

The suggestion has been made in order that the time of filing claims may be more readily established. It appears that in the past some claims placed in the mail within the 3-month filing period have not been received in proper time. Without proof of the time of filing, the Division has been unable, under the law, to allow refund in such cases.

New Technique for Bonding Non-Ferrous Metals Employs Alkali Metal Chloride Mix

Non-ferrous metals which are difficult to join by welding, brazing or soldering can now be bonded by a new and inexpensive process. A solder-like wire, consisting of a mixture of zinc, lithium, potassium and sodium chlorides wrapped in a zinc sheath, is applied to the metal surfaces to be joined after they have been heated to 800°F, the melting point of the wire.

The bond formed is chemical — a eutectic mix of zinc, the alkali metals, and the metals being joined. It is claimed to be strong, corrosion-resistant, and with electrical, physical and chemical properties similar to the metals concerned. Similar or dissimilar surfaces can be bonded using the new technique.

Among the materials which, it is claimed, can be joined by this technique are titanium, zirconium, aluminum, copper, magnesium, zinc, brass, silver, gold, beryllium, platinum, osmium, thorium, uranium, vanadium, tungsten, and some types of steel.

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March ★ **U.S.I. CHEMICAL NEWS** ★ 1958

CONTINUED

ISOSEBACIC

adipic acids were relatively unknown.

Reaction conditions are very closely controlled to dimerize butadiene. If polymerization of butadiene were to occur, yields would be drastically reduced.

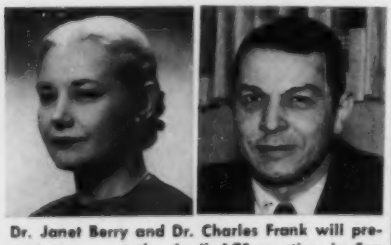
The paper describes prior art on the synthesis and general laboratory procedure, discusses the reaction and isomer distribution, and mentions other applications of the synthesis. It will be presented by Dr. Charles E. Frank, Manager of U.S.I. Organic Research.

Other Alkali Metals Symposium Topics

Some of the other topics planned for the alkali metals symposium are: New developments in liquid metals handling equipment; alkali metals as polymerization catalysts; sodium as a nuclear reactor coolant; manufacture of titanium by sodium reduction; alkali metals derivatives as components of Ziegler-type polymerization catalysts; manufacture of synthetic natural rubber, and large scale manufacture of sodium borohydride.

Paper on Titanium Patent Literature

A paper entitled "Survey of Patent Literature on Preparation of Titanium Metal" will be given for the Division of Chemical Literature at the San Francisco ACS meeting. This report, to be presented by Dr. Janet Berry who manages U.S.I.'s patent section, will graphically illustrate the great growth in titanium technology from patents obtained during the past 35 years.



Dr. Janet Berry and Dr. Charles Frank will present papers at the April ACS meeting in San Francisco.

Zirconium Provides Bright Light in Tiny Flashbulb

A new photoflash bulb is now on the market which is one-fourth the size of conventional bulbs, yet provides the same amount of light. In addition, the new photoflash gives faster light, and is therefore claimed to be the first bulb which can satisfy both box camera users and professionals who require speed.

These results have been accomplished by replacing shredded aluminum with shredded zirconium. The latter metal oxidizes more efficiently, giving 50% more light per unit weight of oxygen consumed. It creates lower pressure at flash peak, permitting higher initial pressure for faster light. It burns cleaner, blackens the bulb less, and so gives more light.

The new bulb costs no more than regular photoflashes, even though zirconium is currently more expensive than aluminum. Increased production by zirconium suppliers like Mallory-Sharon Metals (owned ⅓ by U.S.I.) is expected to make zirconium available in larger quantities for this and other uses.

Methionine Overcomes Urinary Infections

Large doses of methionine have cleared up stubborn urinary tract infections which are resistant to antibiotics or other therapy, according to experiments at an eastern medical school.

Upon oral ingestion, methionine acted as an urinary acidifier, and reduced both the pH and the bacterial count of the urine. After methionine intake, the urine contained an antibacterial substance not present before methionine was given.

Have you a new product to tell the world about?

Make it routine to send your publicity releases to U.S.I. Chemical News, often called the "Front Page of the Chemical Process Industries." Write the Editor at the address below.

TECHNICAL DEVELOPMENTS

Information about manufacturers of these items may be obtained by writing U.S.I.

Polyethylene containers can now be coated with a varnish said to cut static, give high sheen, prevent scuffing. Another coating now available is claimed to reduce oil permeability and oxygen diffusion, give glass-like clarity. **No. 1331**

Ceramic woven fabrics for high-temperature insulation have been introduced which will withstand heat up to 2,000°F., according to producer. Made of aluminum silicate fiber, they are lightweight, flexible, have low bulk factor. **No. 1332**

New silicone compound containing salicyl groups in its structure can now be obtained. It is said to provide sunscreening action, does not wash off easily in water. **No. 1333**

Porous teflon filter cups 12 inches high by 5 inches I.D. can now be obtained for atomic energy use. These cylindrical cups are molded in one operation, are porous in the lower 7 inches only. They remove particles over 3 microns. **No. 1334**

Acylase I, an enzyme obtained from hog kidneys and capable of separating many synthetic dl-amino acids, is now available in developmental quantities. Enzymatic resolution is said to be more economical than other techniques. **No. 1335**

New type of stirring paddle combines centrifugal force, suction, shearing action, counter whirl. Claimed to promote high flow velocity through entire vessel, ensuring maximum dispersion with minimum particle size. **No. 1336**

Acrylic emulsion paint behavior under test exposure in every climatic region in the U. S. is reported in a 56-page brochure just published. Detailed summaries, tables and photos on 3,000 tests which began in 1952-53 are included. **No. 1337**

New infrared analyzer has been announced for measuring concentrations of gases of medical interest such as carbon dioxide, nitrous oxide, cyclopropane, etc. It is expected to be used in such work as pulmonary investigations and research on new anesthetics. **No. 1338**

A method for restoring the flavor of processed foods by adding flavor enzymes is described in a reprint now available. The studies described were carried out on cabbage and related foods, but the method works with many other foods. **No. 1339**

PRODUCTS OF U.S.I.

ALCOHOLS

Ethyl Alcohol (Ethanol): Specially denatured — all regular and anhydrous formulas. Completely denatured — All regular formulas for industrial use, anti-freeze. Pure alcohol — USP 190° — Absolute, N.F., taxfree, taxpaid.

Proprietary Denatured Alcohol Solvents: SOLOX® — General-purpose. FILMEX® — Special, authorized for certain industries, ANSOL® M — Anhydrous, special blend for lacquers, resins, etc. ANSOL® PR—Anhydrous, special blend with higher ester content and solvency for lacquers, resins, etc.

OTHER PRODUCTS

PETROTHENE® Polyethylene Resins

Organic Solvents and Intermediates: Normal Butyl Alcohol, Amyl Alcohol, Fusel Oil, Ethyl Acetate, Normal Butyl Acetate, Diethyl Carbonate, DIATOL®, Diethyl Oxalate, Ethyl Ether, Acetone, Acetoacetanilide, Acetoacet-Ortho-Chloranilide, Acetoacet-Ortho-Toluidide, Ethyl Acetoacetate, Ethyl Benzoylacetate, Ethyl Chloroformate, Ethylene, Ethyl Sodium Oxalacetate, Sodium Ethylate, ISOSEBACIC® Acid, Sebacic Acid, Urethan U.S.P. (Ethyl Carbamate), Riboflavin U.S.P.

Pharmaceutical Products: DL-Methionine, N-Acetyl-DL-Methionine, Urethan USP, Riboflavin USP, Intermediates.

Heavy Chemicals: Anhydrous Ammonia, Ammonium Nitrate, Nitric Acid, Nitrogen Fertilizer Solutions, Phosphatic Fertilizer Solution, Sulfuric Acid, Caustic Soda, Chlorine, Metallic Sodium, Sodium Peroxide, Sodium Sulfite, Sodium Sulfate.

Reactive Metals, Oxides and Salts: Zirconium, Zirconium Oxide, Zirconium Tetrachloride, Titanium, Hafnium, Hafnium Oxide, Hafnium Tetrachloride.

Development Chemicals: Ethylaluminum Sesquichloride, Methylaluminum Sesquichloride, Monomethyl Hydrazine, Triethyl Aluminum, Trimethyl Aluminum, Unsymmetrical Dimethyl Hydrazine.

Animal Feed Products: Antibiotic Feed Supplements, BHT Products (Antioxidant), Calcium Pantothenate, Choline Chloride, CURBAY B-G®, Special Liquid CURBAY, VACATONE®, Menadione (Vitamin K_3), DL-Methionine, MOREA® Premix, Niacin USP, Riboflavin Products, Special Mixes, U.S.I. Permadry, Vitamin B_{12} Feed Supplements, Vitamin D_3, Vitamin E Products, Vitamin E and BHT Products.

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Division of National Distillers and Chemical Corporation
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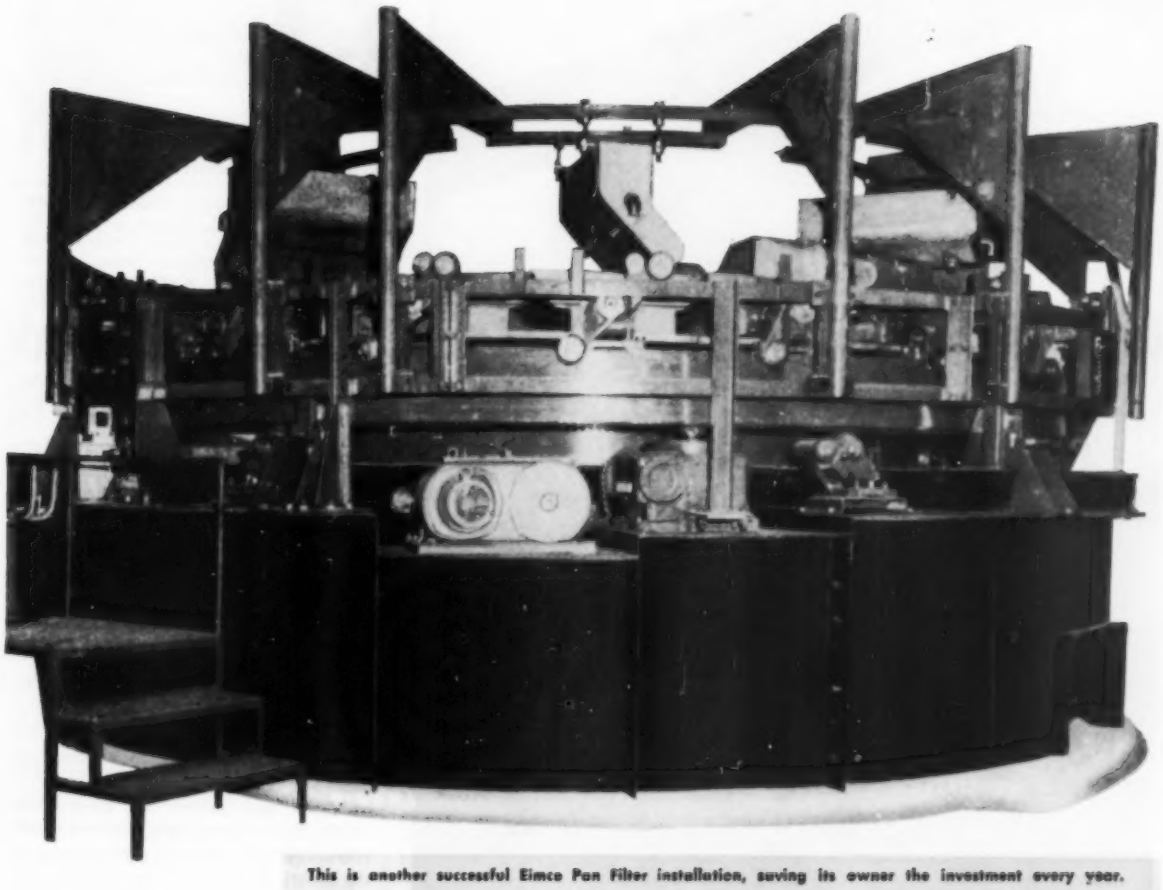

This is another successful Eimco Pan Filter installation, saving its owner the investment every year.

EIMCO PAN TYPE FILTERS FOR ACCURATE WASH CONTROL

Eimco Pan Type Filters are essential for horizontal filter operation where:

1. Complete discharge is desired
2. Accurate wash control is recommended
3. Clean, washed filter media is required
4. High production is necessary
5. Quality product is a must

Each pan is essentially a filter unit in itself. Eimco designs provide for sizes from 20 to 500 square feet of filter area with custom features depending on the products to be filtered. Such items as feed stations, materials of construction, filter medium, wash stations, media washing and many other variations are supplied when customers process people meet with Eimco engineers to establish critical specifications.

Filtration problems are best solved by filtration specialists . . . Write Eimco.

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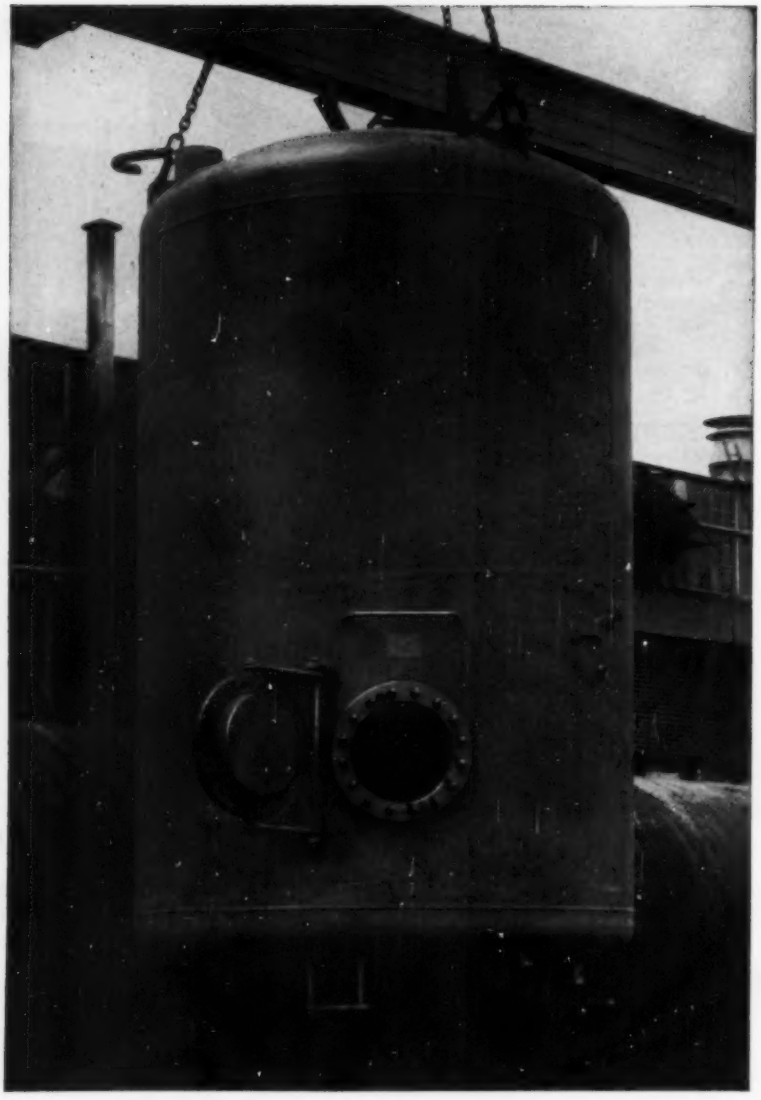

A decade of repeat orders... to the tune of 330 tanks

The only thing unusual about this tank is that it is one of 330 units made at Downingtown to the same basic design.

It measures 8′ in diameter and 12′ high. Material is carbon steel. Interior welds are ground flush and smooth. Operating pressures are nominal.

But the tank represents customer satisfaction with Downingtown workmanship, delivery, price—330 times over.

Send for bulletins detailing our experience and facilities.

SEE US AT THE CHEM SHOW—BOOTH 631

Downingtown Iron Works, Inc.

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Branch offices in principal cities

HEAT EXCHANGERS—STEEL AND ALLOY PLATE FABRICATION

CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS

marginal notes

For That Aerosol Problem

Particulate Clouds: Dusts, Smokes, and Mists. H. L. Green and W. R. Lane (Chemical Defense Experimental Establishment, Porton Down, Wiltshire). D. Van Nostrand Company, Inc., Princeton, N. J., 425 p. (1957), $11.25.

Reviewed by W. L. Faith, Managing Director, Air Pollution Foundation, San Marino, Calif.

British scientists have a knack for combing widely dispersed literature pertaining to a specific subject and restating pertinent facts succinctly and orderly in easily understood language, and this work is no exception. This task, so well done, was made even more difficult by the breadth of the disciplines encompassing the subject: chemistry, physics, meteorology, medicine, biology, engineering, and probably others.

Most chemical engineers deal almost daily with one phase or another of aerosols, whether it be the recovery of dusts and fumes, the production of sprays, spray drying, reduction of entrainment in process equipment, or the solution of an air pollution problem. Accordingly, the chemical engineer will find this book particularly useful for its lucid exposition of fundamental concepts necessary for the solution of most of the aerosol problems he encounters.

Part I. Physics and Physical Chemistry, deals with generation of particulate clouds; the nature and behavior of individual particles; the physics of coagulation, deposition, filtration, etc.

Part II. Industrial and Environmental Aspects, covers, in less detail, methods for collection of particulate matter, including some equipment performance data; health hazards; atmospheric pollution; natural aerosols; uses of particulate clouds.

Each of the chapters in the book is followed by an apparently thorough bibliography (mostly through 1955), which will save the engineer countless hours in literature searching.

The book is well bound and the format is pleasing. Those who deal primarily with aerosols in their daily work, and in fact all chemical engineers, should have the book nearby for constant and ready reference.

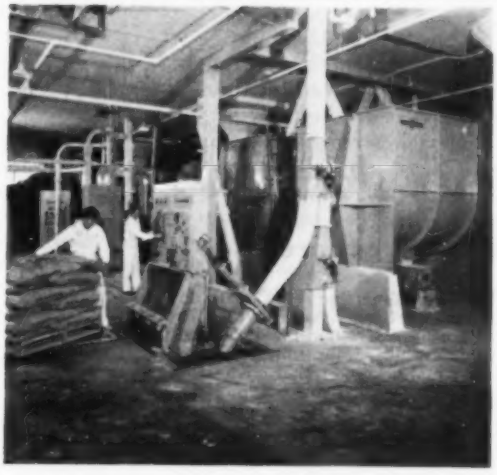
(*Continued on page* 28)

SPROUT-WALDRON Pointers

for Mixing and Blending • Size Reduction
Size Classification • Bulk Materials Handling • Pelleting and Densifying

Published in the interest of better processing by Sprout, Waldron & Co., Inc., Muncy, Penna.

Versatile Starch System Steps Up Capacity



Blending and packaging starches at the new Morningstar Nicol plant is faster, cleaner and more economical thanks to pre-planning for versatility, selection of the right unit machines and air handling.

Vice President Edward Hillary credits advance planning of the entire system with Sprout-Waldron engineers for the extreme versatility. Material may be injected as received, or passed through S-W precrushers and grinders. From one control point, the operator may direct the material into either of two S-W mixers, or bypass them. From the mixers he can discharge and pass through sifters, or if he chooses, bypass them. He can mix and sift, mix without sifting, or dump material from any one of three floors and bypass all mixing and sifting.

Movement of the material is handled by Pneu-Vac, the S-W negative pressure air handling system. This means minimum dusting and trouble-free operation even when moving starch at rates up to 30,000 lbs./hr. Chief Chemical Engineer, Ken Sterrett lived with this installation from the beginning. If you have any questions, he's your man.

— SW —

PELLETS CUT COSTS

Pelleted materials are attracting wide interest in chemical and related process industries because their many advantages are being translated into lower operating costs and fewer problems.

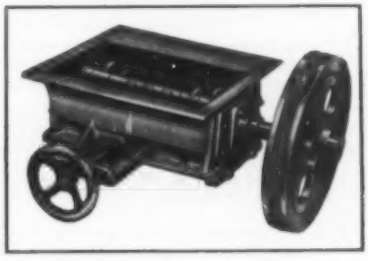
By compressing powders into dense pellets we get material which is dust free; easy to handle, store or package; more economical for drying or cooling; safer and more pleasant to process.

Sprout-Waldron's Pellet Ace has been specified for cellulose acetate, Fullers earth, clay, coal, detergents, graphite, insecticides, kaolin, lignite, polyethylene, sodium nitrate and nitrite, superphosphates, etc. Ask for Bulletin 182 or send your pelleting problems to Joe Grahek, Chief Engineer, Pellet Division.

Salt Slabs Reduced With 18" Crusher

In the manufacture of cellulose sponge it is necessary to reduce the large slabs of glaubers salt, before they can be used efficiently. Although the S-W Single Roll Crusher seemed like a natural for this application, it had to be "adaptioneered" in order to minimize the production of fines which usually occur when handling a material so friable.

"Adaptioneering," the science of adapting standard equipment for special engineering applications is a Sprout-Waldron specialty. For example, Model 104 Single Roll Crusher has been used for reducing



glass, plastics, coal, coke, charcoal, carbon, sulphur, salt, clay, silica gel, urea, dye, bricks, paint pigment, brake linings, roofing shale and a wide variety of other difficult to handle materials. For the facts about this versatile crusher, write for Bulletin 116-A; for assistance in any size reduction problem, contact any S-W representative or drop a note to our Engineering Department.

Sprout-Waldron has a condensed catalog available for your use. Ask for Bulletin 178.

CP/101

IS A-C POLYETHYLENE

THE "X"* FACTOR IN YOUR PROCESS?

Stories of successful application of A-C POLYETHYLENE are pouring in from so many fields and industries that we haven't had an opportunity to explore the apparently limitless uses of this exciting new polymer. So we're asking you! If your field of operation is even remotely similar to those below, it is very probable that A-C POLYETHYLENE can give you increased sales, lower costs and many other advantages. Find out today!

Look what it's done for others!

X **Injection Molders** are getting shorter cycles, complete control of flow, higher gloss, sure mold release, with the ability to mold larger and more intricate parts.

X **Polish Makers** use it in its emulsifiable form and call it the "Polish Maker's Polyethylene". They're getting finish durability, non-slip properties, and rebuffability!

X **Paper Converters** use it as a hot melt and are enthusiastic about the low-cost quality coating it offers. Grease resistance, scuff resistance and single feed to automatic machines are other advantages!

X **Dairy Carton Coaters** add it to waxes for their cartons, getting longer shelf life and reducing flaking, leaking and bulging!

X **Food Packagers** like the smarter, glossier appearance of their packages—less rub-off and scuff. Printing looks better, too!

X **Box Makers** coat interior surfaces of corrugated cartons with an A-C POLYETHYLENE-Paraffin blend to eliminate the need for liners! Scratch from paper fibers on fine finishes is eliminated!

X **Textile Finishers** find A-C POLYETHYLENE surprisingly versatile for sizes or finishes. Excellent hand, sewability, durability, abrasion resistance and many production advantages result from using this polymer!

X **Ink and Paint Manufacturers** are satisfied that A-C POLYETHYLENE adds anti-smudge and scuff resistance characteristics to their products!

X **Slush Molders** use A-C POLYETHYLENE with other polyethylenes and end up with a "brand new" material, giving them simpler production with lowest mold costs. The finished articles are tough, colorful and have fine detail!

X **Film Extruders** are using A-C POLYETHYLENE for faster extrusion rates, lower machine temperatures, easier gauge control and less all around machine stress. A-C POLYETHYLENE is a natural for coloring films. Color concentrates made with A-C POLYETHYLENE produce brilliant, uniformly colored film!

X **Squeeze Bottle Makers** are praising the glossy finish and even color when using A-C POLYETHYLENE. They like the faster molding operation, too!

X* = PROFITS, QUALITY, PRODUCTION...

When it's **A-C® Polyethylene**

LET US SHOW YOU HOW A-C POLYETHYLENE CAN BE THE "X" FACTOR IN YOUR PROCESS!

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Name _____

Company _____

Address _____

City _____ Zone _____ State _____

Marginal notes

(*Continued from page 26*)

Petroleum as an Intermediate

The Chemistry of Petrochemicals, Marvin J. Astle, Case Institute of Technology, Reinhold Publishing Corporation, New York, 267 p. (1956), $6.50.

Reviewed by Thomas F. Doumani, Union Oil Company of California, Los Angeles, California.

In this book the author's objective is to show the importance of petroleum as a chemical intermediate, rather than as a fuel, and to give the chemistry involved in the conversion of petroleum hydrocarbons into commercially useful chemicals. A brief description of the rapidly expanding petrochemical industry is followed by a chapter on the syntheses of paraffin hydrocarbons covering the preparation of synthesis gas and the Fischer-Tropsch synthesis. This is followed by chapters dealing with the reactions of paraffin hydrocarbons, preparation of olefins, reactions of olefins, polymerization and alkylation of olefins, diolefins, acetylene, naphthenes, aromatic hydrocarbons, olefin oxides, alcohols and ethers, aldehydes and ketones, acids, acid anhydrides and esters, amines and nitriles. The writer has used many of the most important journal articles relating to specific petrochemicals and has supplemented the information and data therein, where necessary, with patents. Probable reaction mechanisms are given for some of the petrochemicals.

This work should be valuable to those workers in the petroleum and chemical fields who desire a brief description of the chemistry of the chemicals derived from petroleum.

Plastic Sheet Forming. R. L. Butzko, Reinhold Publishing Corporation, New York, N. Y., VIII plus 181 pages.

Polyamide Resins. D. E. Floyd, Reinhold Publishing Corporation, New York, N. Y., VIII plus 230 pages.

The first book, not intended to answer all questions confronting the sheet-forming industry but rather to bring the scattered information together to prove useful to both the technical and nontechnical reader, covers such subjects as applications of sheet forming, selection of the proper materials, commercial machinery, etc.

In the second work the general properties of the polyamide resins are discussed and the basic chemistry of the polyamides. Other subjects reviewed are molding, casting, extrusion, and future trends.

(*Continued on page 30*)

No Excessive Heating

New Rectifier Cooling System Prevents Heat Build-up and Damage

when ac Power Fails

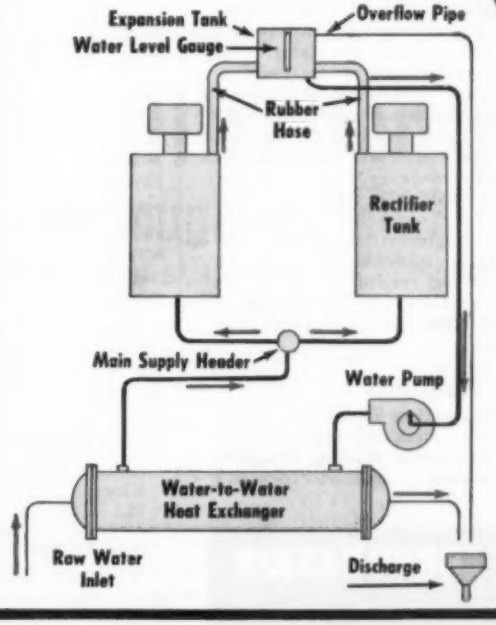
A SAFER, more effective cooling system in the Allis-Chalmers rectifier continues to circulate water *even when an ac power failure stops the water pump.* Heat and steam are dissipated before they can develop to the danger point.

The new system features an expansion tank that extends the full length of the rectifier frame with short vertical connections from each tube. With warm water continuing to flow freely upward, a thermo-siphoning action draws cooler water into the tubes. Build-up of excessive temperatures is prevented. Steam pockets are kept from forming. Subsequent water loss from the recirculating cooling system is minimized.

Successful operation in hundreds of installations is your assurance of the complete reliability of Allis-Chalmers mercury arc rectifiers. Contact your nearby A-C office or write Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wis.

How the System Works

Water is normally pumped through the water-to-water heat exchanger to the main supply header from where it circulates through rectifier tubes picking up heat. Hot water flows up through the short connections to expansion tank and back down to suction side of water pump.



ALLIS-CHALMERS Mercury Arc Rectifiers

Factory-packaged units cut installation time and costs. Sealed tube rectifiers are supplied in completely enclosed or open types. Here is a typical, completely enclosed, 1000-kw, 250-volt rectifier for steel mill service.

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THE DEPENDABILITY OF A PRODUCTION DRYER

SARGENT'S NEW PILOT PLANT DRYER

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CHEMICALS
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PIGMENTS
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LATEX
PHARMACEUTICALS
PLASTICS
SODA LIME
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Each drying section, or any arrangement of groups of sections, can be zoned and controlled independently to provide widest possible variation of temperature, humidity, etc., where needed. Production technique and settings are determined accurately, transferred to the production dryers without need for adjustment. Additional sections are added easily and quickly at your plant. They are delivered as a complete unit with motor, fan, heating coils and conveyor in place. Compact, made in two sizes, the smaller being only 4'-0" high and 3'-9" wide. Uses gas, electricity or steam for heating element. Simple adjustment to regulate conveyor speed. Fully instrumented, has all necessary controls and recording charts. It's a little giant of versatility — invaluable in the modern, cost-conscious pilot plant. Let us give you details.

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Sargent Dryers for Lab, Pilot Plant, Production (Conveyor, Tray, Tunnel, Truck) — easiest, speediest to install . . . less time than any other dryer on the market. Also Sargent Feeds, Automatic, Mixing, Weighing feeds . . . Extruders . . . Granulators . . . Coolers . . Special Processing Machinery.

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Marginal notes

(Continued from page 28)

Combustion Applications

Selected Combustion Problems II. Advisory Group for Aeronautical Research and Development, North Atlantic Treaty Organization, Butterworth Scientific Publications, London (1956), 495 p.

Reviewed by R. B. Lawhead, Rocketdyne, Division of North American Aviation, Inc., Canoga Park, California.

Articles covering the general topics of transport phenomena, ignition and altitude behavior, and scaling of aeroengines which were presented at the Agard Combustion Colloquium at Liege, Belgium (December, 1955) are collected in this volume. In addition to the papers, a considerable amount of space has been devoted to the discussions, comments, and authors' replies which followed the formal presentations. These discussion sections form a stimulating augmentation of the technical presentations.

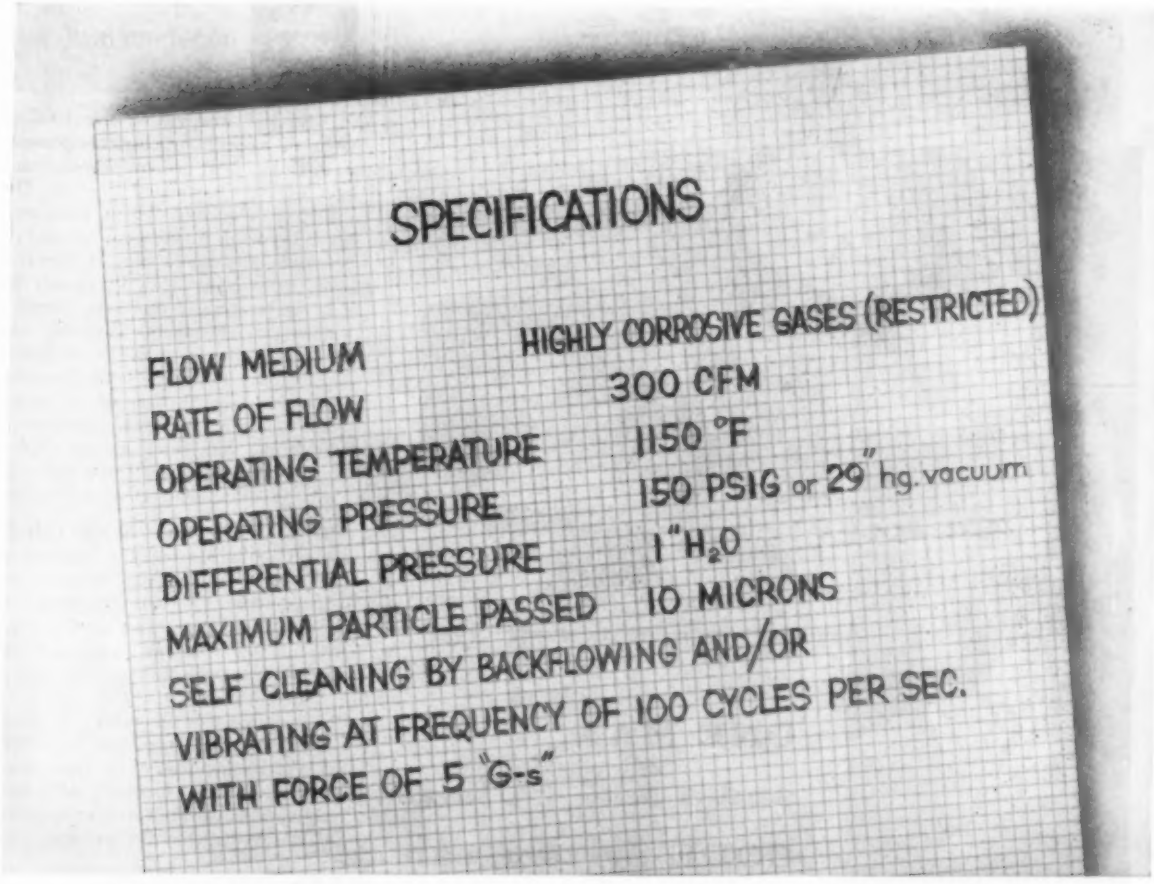
The fundamental aspects of combustion phenomena are emphasized in seven papers grouped under the two headings—Ignition and Flammability, and Transport Properties. The Ignition section is keynoted by the presentation of Lewis and von Elbe, while the Transport Properties section is introduced by a discussion of the fundamental equations of aerothermochemistry by von Karman.

The remaining eleven papers are grouped into three divisions entitled Aircraft Engines and Fuels; High Altitude Combustion Problems; and Similarity, Scaling, and Fundamental Parameters in Combustion. These papers consider the applications of combustion phenomena in air-breathing and rocket-propulsion systems. Discussions of scaling in rockets is particularly timely.

The proceedings complement the information presented in the 3rd, 4th, 5th, and 6th Symposia (International) on Combustion and should be a part of any working level library on combustion processes.

Ceramic Fabrication Processes. W. D. Kingery, The Technology Press of M.I.T., Boston, Mass., and John Wiley & Sons, Inc., New York, N. Y., xi plus 235 pages (1958).

The participating contributors to this volume were from the academic, research, development, production, and administration fields, and their companies' major interests were in carbon, clay ware and clay supplies, electronic, chemicals, metallurgy, aeronautics, refractories, ferrites, ferroelectries, glass, atomic energy, and others.


SPECIFICATIONS
FLOW MEDIUM HIGHLY CORROSIVE GASES (RESTRICTED)
RATE OF FLOW 300 CFM
OPERATING TEMPERATURE 1150 °F
OPERATING PRESSURE 150 PSIG or 29" hg. vacuum
DIFFERENTIAL PRESSURE 1" H_2O
MAXIMUM PARTICLE PASSED 10 MICRONS
SELF CLEANING BY BACKFLOWING AND/OR
VIBRATING AT FREQUENCY OF 100 CYCLES PER SEC.
WITH FORCE OF 5 "G-s"

Do you have filtration problems as tough as this?

PUROLATOR'S ENGINEERING SALES STAFF WILL HELP YOU SOLVE THEM

The requirements above are not hypothetical . . . they are typical of specifications to which Purolator has designed and built filters. The filtering elements designed for this application combine two forms of a porous metal media to obtain the required filtration qualities with the structural strength needed to withstand the punishment of the self-cleaning action – plus the temperature gradients and the effects of corrosive materials.

Purolator's engineering staff specializes in designing and building filters for difficult applications like this. The emphasis is on engineering, by a staff of "Q" and "L" cleared filtration experts, backed up by complete manufacturing facilities, able to produce filters or separators of any known media to operate within these wide ranges of conditions:

TEMPERATURES: from —420° to 1200° F.

PRESSURES: from a nearly perfect vacuum to 6,000 p.s.i.

RATES OF FLOW: from drop by drop to thousands of GPM.

DEGREES OF FILTRATION: from submicronic to 700 microns (in various media).

This complete filtration service, for the toughest problems in nuclear and chemical applications, is available only at Purolator. Purolator's engineers are ready to work on your requirements. If you have an *urgent* need for specially designed filtration systems, call Jules Kovacs, Vice President in charge of Research and Development and Product Application . . . or send him the details of your application.

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ONE MAN, and a *Varec* PULSE CODE System, can gauge and record 100 tanks in 12.3 minutes—AUTOMATICALLY

Quite a job for one man—and quite a saving for his employer. A saving in labor, time and overflow losses, and an increase in production efficiency. The secret, of course, is the "Varec" PULSE CODE equipment wisely specified by the farm operator. He has discovered what thousands of successfully operating "Varec" installations have been proving for years: that automation *means* reduced operating costs, and automation by "Varec" *guarantees* it.

"Varec" has been the leader in the field of automatic tank gauging since its inception. This progressive leadership, coupled with over 30 years experience in faithfully supplying the nation's petro-chemical industry with products noted for their dependability and excellence of design and manufacture, has resulted in the "Varec" PULSE CODE Telemetering System—the finest in the field.

"Varec" PULSE CODE reads SAFE—if a pulse is lost or gained you get no reading, not an incorrect reading. "Varec" PULSE CODE can give you an accurate, dependable telemetering system—over unlimited distance using any type single communication channel—for remote gauging of liquid level, temperature reading, and remote control of valves and pumps. It can provide an automatically printed record through an electric typewriter or tape printer. It does the work formerly requiring many field men, infinitely more accurately, and has an amazingly fast pay-out.

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about our authors

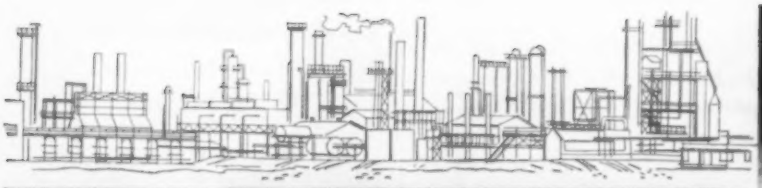
"Heavily" involved in the development of a perchloroethylene process, **J. J. Lukes** is at present process manager of the Chlorinated Products Division of Diamond Alkali Company, involving work on the improvement of processes and operations of the five plants of the division. Previously he held the position of research manager, Chlorinated Products Division and assistant manager of the development department. Formerly with Standard Oil of Indiana, he served as group leader in the research department. During the war, while in the employ of Standard, he spent three years in work on Manhattan District Project.

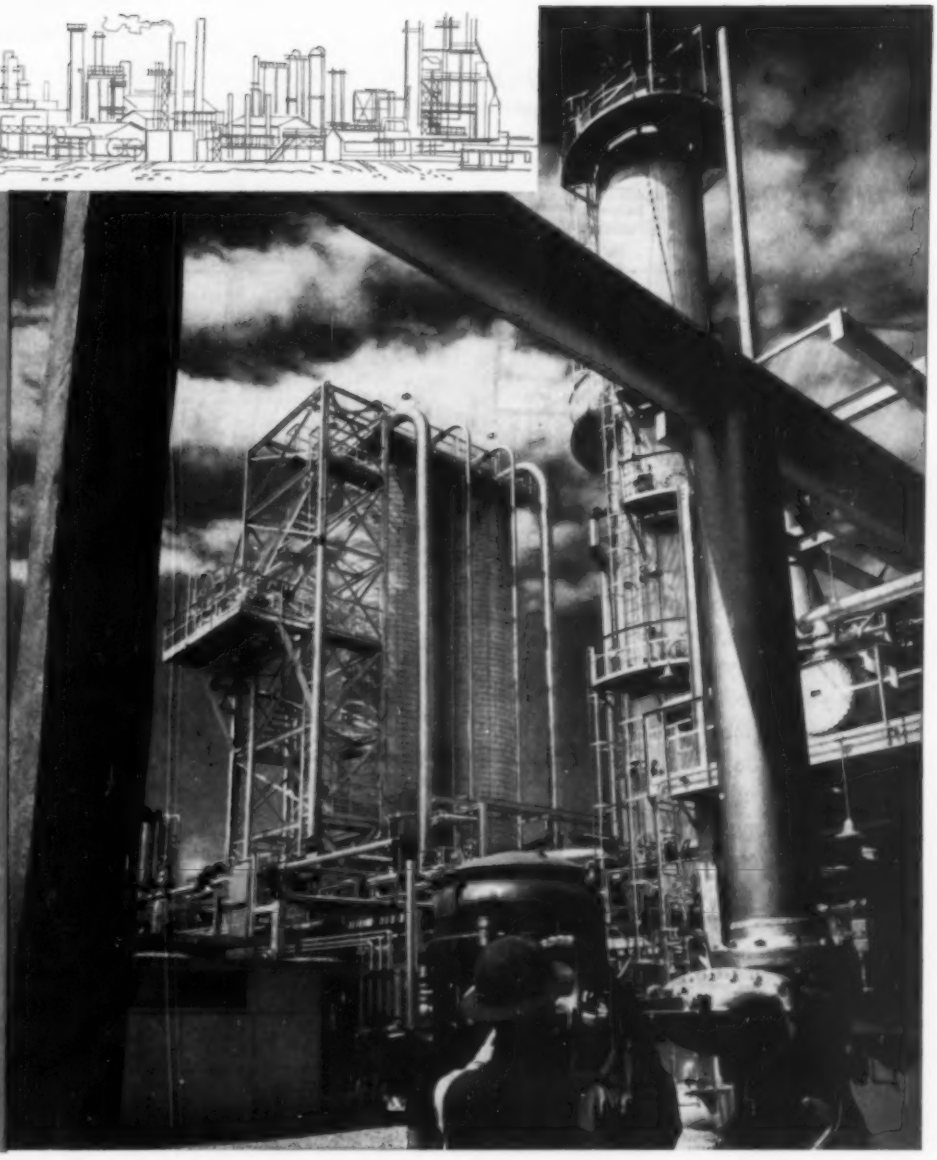
E. L. Mongan and **W. S. Gilfoil**, consultant supervisor and consultant, respectively, in chemical engineering section, of Du Pont's Engineering Department, have been interested and active in the economic and technical analyses of projects for new plants and processes. Their work has been directed towards insuring technical adequacy for design and providing satisfactory facilities at minimum cost. The continuous process evaluation recommended in their article, suggests an improved method of gaining these ends.

At present **A. N. Leibovic** is associated with British Oxygen Research and Development—engaged in engineering research and is responsible for the application of mathematical techniques and recent developments in the operations and problems of the company. His work on multiple-effect evaporation was done while he was a member of the Research Department, Chemical Engineering Section at Courtaulds, Coventry. There he was engaged in work in adsorption, fluidization, mixing.

The intellectual challenge of chemical engineering and its prospects for technological advances, sparked the interest of **E. F. Johnson** in the field of automatic process control. Dr. Johnson, associate professor of chemical engineering at Princeton University, is a research investigator and design engineer with varied experience in industry, research, and teaching. Since the summer of 1955, he has been affiliated with Project Matterhorn, a classified government project in the field of thermonuclear reactions for the production of power. His main contribution to the field of control sys-

(Continued on page 34)





Coke produced in the Blaw-Knox built refinery unit is used directly in making electrodes for aluminum production.

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are a growing factor in two great industries ... petroleum and chemicals

Wide experience, gained through long association with diversified problems in both petroleum and chemicals, as well as in petrochemicals, enables Blaw-Knox engineers to meet your most exacting requirements in designing, engineering and building plants in all three process areas. When planning new or expanded facilities, investigate how this specialized background can serve you, too.

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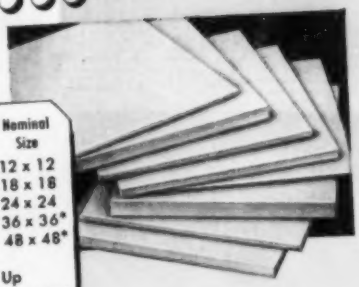
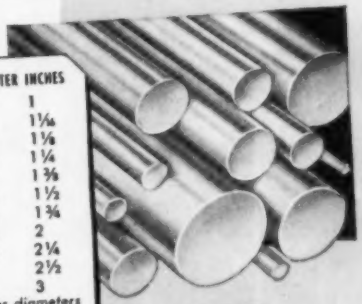


Thickness Inches	Nominal Size
1/16"	12 x 12
3/32	18 x 18
1/8	24 x 24
3/16	36 x 36*
1/4	48 x 48*
3/8	
1/2 & Up	

* Can be furnished in 1/2 sheets

SHEET



DIAMETER INCHES	
1/4	1
5/16	1 1/4
3/8	1 1/2
7/16	1 1/4
1/2	1 3/8
9/16	1 1/2
5/8	1 3/4
3/4	2
7/8	2 1/4
	2 1/2
	3

Other diameters on specification

ROD

TYPICAL SIZES INCHES	
O. D.	I. D.
3/8	1/4
1/2	3/8
3/4	1/2
1	3/4
1 1/2	1
2 1/2	1 1/2
3	1 3/4

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Since the availability of Teflon, "John Crane" engineers have worked with Industry to successfully solve innumerable problems and develop new applications. *You can benefit from their experience and know-how.*

Characteristics of Teflon

CHEMICAL
Completely inert.

ELECTRICAL
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Extremely low power factor.

THERMAL
Temperature range
−300° to +500° F.

MECHANICAL
Strong, flexible, weather resistant.

LOW COEFFICIENT OF FRICTION
Absolutely non-stick.

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JOHN CRANE CRANE PACKING COMPANY 38 YEARS INDUSTRIAL PROGRESS

About our authors

(*Continued from page 32*)

tems engineering has been to emphasize its pertinence to the field of chemical engineering.

The James Turner Morehead Medal of the International Acetylene Association will be awarded for 1957 to **Robert C. Swain,** vice-president in charge of research and development, American Cyanamid Co., for "leadership in developing a commercial process for melamine and related derivatives of calcium carbide."

E. W. James, who also writes on control systems engineering, is control supervisor in the Technical Computation Group within DuPont's Engineering Dept. For five years previously, James worked in process dynamics in the Instrumentation Section of the Engineering Dept. His present field of specialty is in analog simulation.

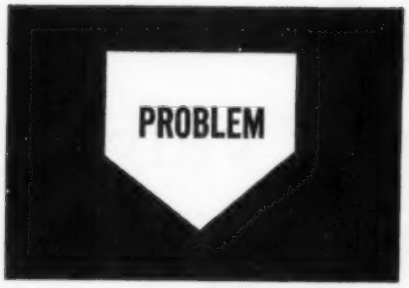
Charles Bartels, whose writings have been seen in the columns of CEP in the past, authors in this issue a resume of cost trends and cost control in the processing of pharmaceuticals—a field with special problems. Bartels is department head of chemical development pilot plant of the Squibb Institute for Medical Research, Division of Olin-Mathieson.

Arthur Michel, who tells about models, is Fluor's principal designer in charge of plant and piping layout. This group began the development of a model program six years ago.

Coleman J. Major, author of the article bringing us up to date on the technology of the all-important boron hydrides, is with American Potash and Chemical Corp. at Henderson, Nevada. Prior to this, he was associate professor of chemical engineering at the State University of Iowa.

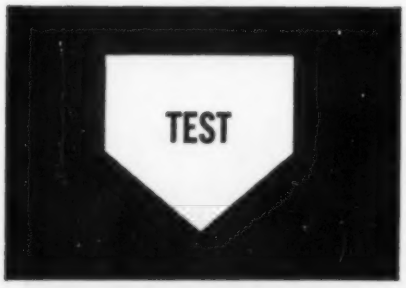
V. N. Mackiw, one of the authors of the article on the chemical production of nickel, studied in Germany and Belgium, has been with Sherritt Gordon since 1949. He is director of the Research and Development Division. **R. L. Benoit** studied in France and was for years head of research for S-G; is now a professor at Laval U., Quebec. **R. J. Loree** studied at Queens University, Ontario, and is now assistant superintendent of the Metals Plant. **N. Yoshida** is a U. of Alberta chemical engineer, is presently head of Project Development.

Charles D. Harrington (uranium dioxide) has been working on producing this material since Mallinckrodt entered the field in 1942.



Drying an extremely heat-sensitive herbicide. If the dried product reaches 235°F. it decomposes and develops flammable gases. Another problem is that the stability of the dried herbicide decreases with any increase in moisture content. It is therefore necessary to keep the moisture content in the dried product very low (not more than 1% H_2O). Due to excessive decomposition, previous drying methods were able to give only 60% yield.

"GENTLE-IZED" Spray Drying by NERCO-NIRO



An extensive series of tests to determine optimum operating conditions and special design details were carried out in the NERCO-NIRO Research Laboratories at Netcong, N. J. Later, 2,000,000 lbs. of herbicide were custom-dried for market research and preliminary commercial supplies.

Two years of trouble-free operation in our client's plant has proved the efficiency of NERCO-NIRO "Gentle-ized" Spray Drying. 2,000 lbs. of herbicide powder are produced per hour, at 99% yield, in a NERCO-NIRO Spray Dryer.

Herbicides, fungicides and fine chemicals that are difficult to handle can be processed for maximum yield, product quality and economy—the NERCO-NIRO way.

Consult our Spray Dryer Engineers on your processing problems

Nerco-Niro Spray Dryer Div'n.

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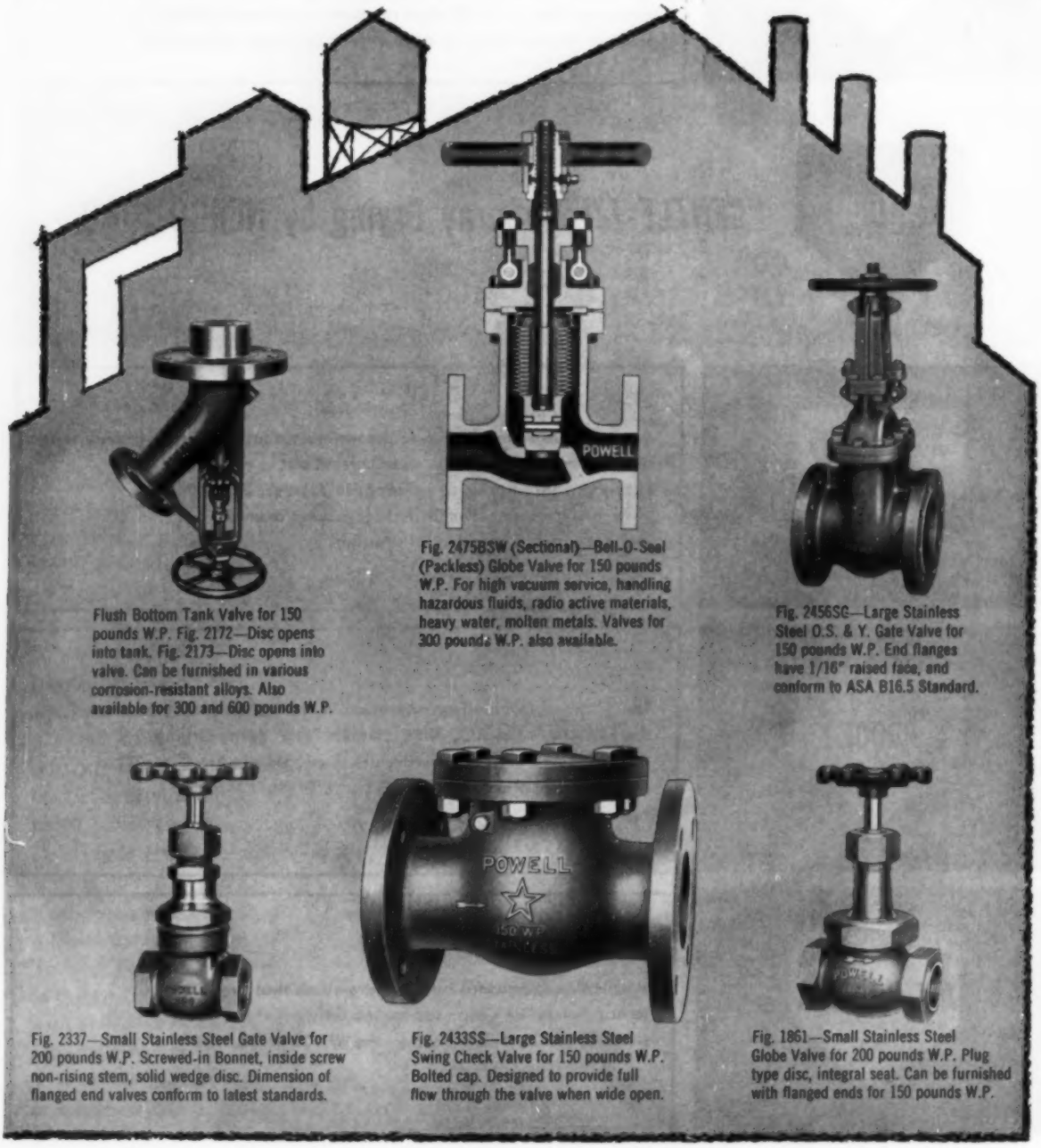

Flush Bottom Tank Valve for 150 pounds W.P. Fig. 2172—Disc opens into tank. Fig. 2173—Disc opens into valve. Can be furnished in various corrosion-resistant alloys. Also available for 300 and 600 pounds W.P.

Fig. 2475BSW (Sectional)—Bell-O-Seal (Packless) Globe Valve for 150 pounds W.P. For high vacuum service, handling hazardous fluids, radio active materials, heavy water, molten metals. Valves for 300 pounds W.P. also available.

Fig. 2456SC—Large Stainless Steel O.S. & Y. Gate Valve for 150 pounds W.P. End flanges have 1/16" raised face, and conform to ASA B16.5 Standard.

Fig. 2337—Small Stainless Steel Gate Valve for 200 pounds W.P. Screwed-in Bonnet, inside screw non-rising stem, solid wedge disc. Dimension of flanged end valves conform to latest standards.

Fig. 2433SS—Large Stainless Steel Swing Check Valve for 150 pounds W.P. Bolted cap. Designed to provide full flow through the valve when wide open.

Fig. 1861—Small Stainless Steel Globe Valve for 200 pounds W.P. Plug type disc, integral seat. Can be furnished with flanged ends for 150 pounds W.P.

For every flow control problem Powell offers more kinds or types, available in the largest variety of metals and alloys to handle every flow control requirement. Powell distributors are located in all principal cities and maintain inventories to fill almost any need. For special engineering problems, write direct to:

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CAN THE PUMP BE PRIMED?

The great debate goes on—are we going to have a depression or aren't we? And if we are, what can be done about it and what **should** be done about it? By now everyone, with a few lucky exceptions, which include the drug manufacturers for example, recognizes that we are in a "recession"—though opinions differ widely as to how long it will last and how deep it will be. There is one school of gloomy thought among the fraternity of economists that holds that no one, including the government, can do anything effective about stopping a recession or avoiding a depression if it is on the way. It is the opinion of some that deficit financing and desperate pump priming in the 1930's proved largely ineffectual.

This is not to say that conditions now are in any way comparable to the circumstances, including wild speculation on all fronts, that brought about the 1929 crash. There is no credit crisis in sight, and there have been few excesses either in business or in finance that seem to have laid the groundwork for serious trouble. But we have had ten years of prosperity and of heavy spending by both consumers and industry, so at least a pause is in order. There is therefore basis for believing that the recession may not be a deep one, but as yet there is no way of knowing how long it may last.

Confidence in the Capital

Washington talks with confidence as Washington must. The President predicted that the beginning of the end of the downturn will come in March and other government pundits are looking for an upturn by summer. However industrial and financial district economists are less hopeful. The economist for the Ford Motor Co., for example, does not expect an upturn until the end of the year although he does not foresee a deep recession or a depression. An economist for one of the larger steel producers expects a pick-up in that business in the last half of the year but does not think overall operations for 1958 will be much over 65%. This of course infers that operations in the last half should be quite a bit better than the present low ebb of under 60%. Other business news has continued to be bad. Recent reports on carloadings show a drop of 20% below a year ago. Reports from the oil industry continue to be blue. Automobile production is down well below 1957 comparable levels and inventories are said to have risen to as much as three months supply with some of the big firms. Plant layoffs confirm the industry's doubts of an immediate change in their outlook. There has even been some indication that chemical firms are curtailing or at least stretching out their budgets for plant expansion.

Meanwhile a small rash of dividend cuts in the weaker or more cyclical industries, some of them quite drastic, has appeared in the news. However most of these cuts were not accompanied by any great weakness on the market, no doubt because declines in the stocks had already discounted the bad news.

On the more cheerful side there has been a modest increase in the rate of home building to the annual rate of 1,030,000 from 970,000 last December. If this should continue, it would have a more helpful effect on the economy than some of the government measures being taken or being contemplated. A great deal of money is involved, because 100,000 houses probably mean an expenditure of say $2 billion.

Easy Money

The Government has taken a number of steps to ease credit and increase the supply of money. Tight money is given the credit for causing the start of the downturn. Whether easing money will turn things the other way quickly is doubtful. Steps taken by the government so far have had little effect. The reduction in margin requirements for stock buying to 50% from 70% did not help the stock market appreciably. The next major action to cut Federal Reserve requirements added about $500 million to commercial bank reserves and theoretically will add around $3-billion to the credit pool. This action again had no effect on the stock markets.

Now government officials are talking about tax cuts to increase spending power and perhaps later a massive program of public works, road building, and even slum clearing. While a tax cut would be pleasant, it could hardly amount to more than a few extra dollars each month in the individual's paycheck. A cut on industry taxes would probably have more practical results but here again the effect would not be felt immediately.

Admitting that the nation cannot afford a depression here because of its repercussions on our friends and customers abroad, it seems probable that more and more drastic inflationary measures will be taken unless the business tide turns.

The one thing that appears likely at the moment is that it will take another six months for easier money and increased defense spending to be translated into orders, buying, and increased employment.

CAN THE PUMP BE PRIMED?

The great debate goes on—are we going to have a depression or aren't we? And if we are, what **can** be done about it and what **should** be done about it? By now everyone, with a few lucky exceptions, which include the drug manufacturers for example, recognizes that we are in a "recession"—though opinions differ widely as to how long it will last and how deep it will be. There is one school of gloomy thought among the fraternity of economists that holds that no one, including the government, can do anything effective about stopping a recession or avoiding a depression if it is on the way. It is the opinion of some that deficit financing and desperate pump priming in the 1930's proved largely ineffectual.

This is not to say that conditions now are in any way comparable to the circumstances, including wild speculation on all fronts, that brought about the 1929 crash. There is no credit crisis in sight, and there have been few excesses either in business or in finance that seem to have laid the groundwork for serious trouble. But we have had ten years of prosperity and of heavy spending by both consumers and industry, so at least a pause is in order. There is therefore basis for believing that the recession may not be a deep one, but as yet there is no way of knowing how long it may last.

Confidence in the Capital

Washington talks with confidence as Washington must. The President predicted that the beginning of the end of the downturn will come in March and other government pundits are looking for an upturn by summer. However industrial and financial district economists are less hopeful. The economist for the Ford Motor Co., for example, does not expect an upturn until the end of the year although he does not foresee a deep recession or a depression. An economist for one of the larger steel producers expects a pick-up in that business in the last half of the year but does not think overall operations for 1958 will be much over 65%. This of course infers that operations in the last half should be quite a bit better than the present low ebb of under 60%. Other business news has continued to be bad. Recent reports on carloadings show a drop of 20% below a year ago. Reports from the oil industry continue to be blue. Automobile production is down well below 1957 comparable levels and inventories are said to have risen to as much as three months supply with some of the big firms. Plant layoffs confirm the industry's doubts of an immediate change in their outlook. There has even been some indication that chemical firms are curtailing or at least stretching out their budgets for plant expansion.

Meanwhile a small rash of dividend cuts in the weaker or more cyclical industries, some of them quite drastic, has appeared in the news. However most of these cuts were not accompanied by any great weakness on the market, no doubt because declines in the stocks had already discounted the bad news.

On the more cheerful side there has been a modest increase in the rate of home building to the annual rate of 1,030,000 from 970,000 last December. If this should continue, it would have a more helpful effect on the economy than some of the government measures being taken or being contemplated. A great deal of money is involved, because 100,000 houses probably mean an expenditure of say $2 billion.

Easy Money

The Government has taken a number of steps to ease credit and increase the supply of money. Tight money is given the credit for causing the start of the downturn. Whether easing money will turn things the other way quickly is doubtful. Steps taken by the government so far have had little effect. The reduction in margin requirements for stock buying to 50% from 70% did not help the stock market appreciably. The next major action to cut Federal Reserve requirements added about $500 million to commercial bank reserves and theoretically will add around $3-billion to the credit pool. This action again had no effect on the stock markets.

Now government officials are talking about tax cuts to increase spending power and perhaps later a massive program of public works, road building, and even slum clearing. While a tax cut would be pleasant, it could hardly amount to more than a few extra dollars each month in the individual's paycheck. A cut on industry taxes would probably have more practical results but here again the effect would not be felt immediately.

Admitting that the nation cannot afford a depression here because of its repercussions on our friends and customers abroad, it seems probable that more and more drastic inflationary measures will be taken unless the business tide turns.

The one thing that appears likely at the moment is that it will take another six months for easier money and increased defense spending to be translated into orders, buying, and increased employment.

opinion and comment

A COSTLY CONTRADICTION

One consequence of our current domestic recession is that fewer new plants are being built. As a result, our engineer-constructor organizations—who employ large numbers of chemical engineers—must supplement the diminished domestic market for their services by turning to foreign customers. But here too, they are meeting difficulties.

The Federal agencies that make loans available to foreign countries do not, as a rule, advance funds to pay for the services of American engineer-constructors. This is particularly true when the enterprise in question is not government-sponsored. These agencies do, on the other hand, make arrangements for deferred repayment for American process plant equipment. And so there is the contradiction that U.S. funds are made available for the purchase of equipment, but are not made available to pay for the design and engineering of the processes which make the use of the equipment possible.

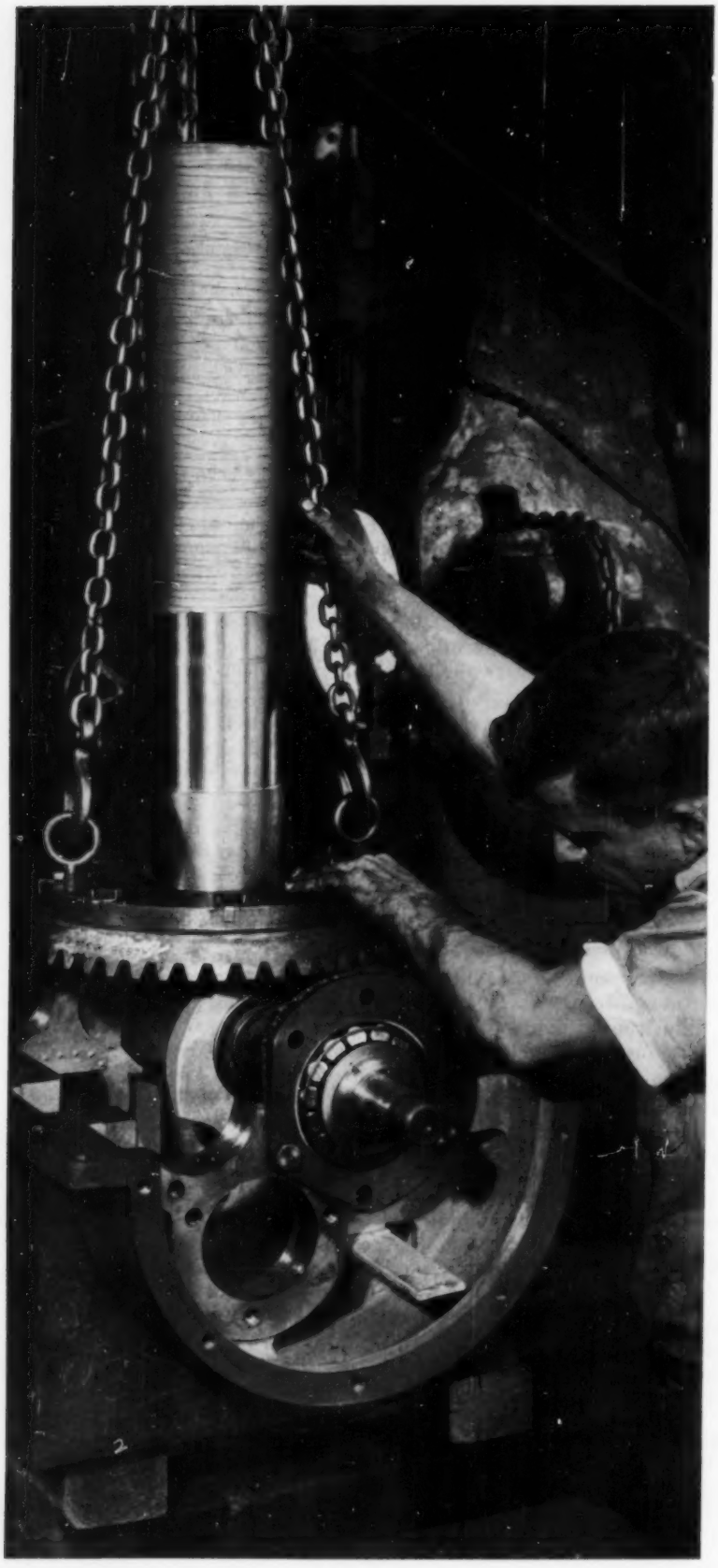
In the past, American engineer-constructors have had to arrange private financing for their fees, usually with U.S. banks. At best, such financing added difficulty and delay to the handling of jobs in foreign countries, and retarded the export of American processing know-how.

Difficult though that situation may have been, it has now grown worse. The private funds to which our engineer-constructors turned in the past are now less available than they have been. Reasons for this are several: money is generally tighter, and certain customer nations, particularly in the Middle and Far East, seem more susceptible to war or civil insurrection.

Meanwhile, competition from European engineer-constructors has been diverting further business from U.S. firms. In some respects, this competition was not formerly regarded as too serious a threat because of the high regard that customer nations have for U.S. know-how. But the threat offered by our competitors in England, Germany, France, and Italy, has grown far more acute. This has not been because of the superiority of their services but because of the facility with which their services can be bought. For, in each of these countries, the government underwrites the insurance for exports to foreign countries. Under their package plans, private capital that is invested abroad is protected against loss caused by currency revaluation, expropriation, war, and the more conventional credit problems of insolvency, default, and so on. In a great number of cases, this insurance makes the difference between a customer's being able to go ahead with a project, and the loss of the order.

Surely this is a self-imposed inequity that the appropriate agencies of our government should correct: the services of our engineer-constructors should certainly be available in the world marketplace on an equal basis with other countries. And from the standpoint of maintaining full employment of the chemical engineers in these organizations, of maintaining a high level of activity in that area, and of safeguarding our national prosperity and security, government action to correct this inequity would seem particularly well-advised.

J.B.M.



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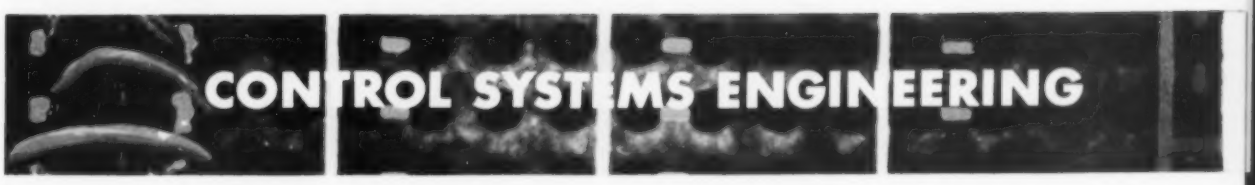


the challenge

Ernest F. Johnson | Princeton University
Princeton, New Jersey

The aim of chemical engineering technology is to increase the productivity of our invested capital and our labor without limit. Nothing less is sought than the fully automatic, continually optimized plants, industries, and economy. The technical principles involved in this endeavor, like any other basic principles, are quite simple, and should be a part of our basic working knowledge. While the art of control engineering has served us in the past, the increasing interest in high-speed reactions and processes and the continuing battle to reduce investment requirements and operating expenses make it increasingly important that a precisely quantitative consideration of the control problem be a vital part of any projected plant study or design.

The field of chemical engineering is a broad one, overlapping many branches of science and engineering. Because of its breadth and because of the diverse activities that chemical engineers engage in, it is not easy to define chemical engineering precisely. Perhaps the simplest and least restrictive definition is that it is that branch of engineering which serves the technology of the chemical process industries.

In order to balance our perspective of chemical engineering we must reexamine our conceptual organization of the field. A simple way to do this is to consider what kinds of questions chemical engineers must answer in solving process problems. There appear to be only four such *kinds* of questions, and these are asked whether the problem is one of performance analysis or one of design.

1. What physical or chemical limitations are imposed on the processes involved?
2. What amounts of material, energy, and money are involved?
3. What types and sizes of physical equipment are required?
4. What quality of performance is involved?

Concepts Involved

Each of these question types has associated with it a particular concept. In the first question the concept is thermodynamic equilibrium; in the second, conservation; in the third, rate processes or kinetics; and in the fourth, control.

Equilibrium fixes the limits beyond which no process can go. The concept of conservation provides the basis for accounting procedures to fix amounts.

HISTORY

Historically chemical engineering emerged as a separate branch of engineering as a result of the recognition (a) that certain unit operations were common to all the process industries and (b) that a sound knowledge of these operations made an engineer useful in any of the industries despite the wide variety of their products. Chemical engineering education, of course, capitalized on the unification afforded by the concept of the unit operations with the result that even today most of our chemical engineering curricula are heavily loaded with instruction in the unit operations.

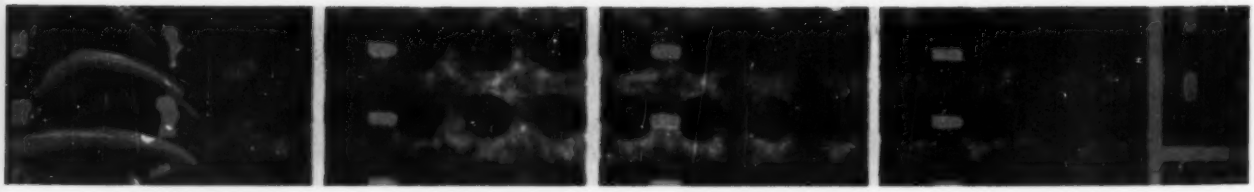
Unfortunately our preoccupation with these unit operations has warped our perspective. Chemical engineering is not alone concerned with the design and performance of individual bits of apparatus wherein some unit operations take place. It is equally well concerned with the over-all performance of the integrated process plant and indeed with the over-all performance of a whole works and ultimately with the entire corporate enterprise. Nor is chemical engineering solely concerned with the unit operations as individual processes. Chemical reactors and nuclear reactors are units of critical importance in process sequences, and an understanding of their principles is as important in modern process technology as an understanding of the unit operations.

Familiar examples are the material balance, the energy balance, the momentum balance, and the economic balance. Kinetics in the context of these basic concepts includes chemical and nuclear rate processes as well as the physical rate processes which underlie the unit operations, namely, thermal transfer, momentum transfer, and mass transfer.

The fourth concept, control, has been of little formal concern to chemical engineers until only very recently. It is quite different from the other three concepts in that it is not directly concerned with amounts, sizes, and efficiencies, but rather with the quality of performance or the behavior of process systems. It has two aspects, namely, economic control and automatic process control.

These four concepts may be regarded as an inclusive categorization of the basic fundamentals of chemical engineering. Actually the first two concepts, equilibrium and conservation, are directly derivable from the second and first laws of thermodynamics, and hence may be lumped together. The basic concepts then may be called simply *thermodynamics, kinetics,* and *cybernetics,* the last term signifying control in its broadest implications.

An argument for treating the basic concepts in the order: equilibrium—conservation—kinetics—control is that a typical appraisal of a new process invokes the concepts in that sequence.



First one examines the physical and chemical feasibility; next one determines the gross amounts of raw materials, energy requirements, product yields, and frequently at this stage a preliminary economic appraisal; then the specific process equipment needs are assayed; and finally the performance of the connected process units is considered. What is involved is a succession of integrations beginning first with notions of potentiality, then leading into process units from integrations of conservation and rates, and subsequently into operating process plants.

If the foregoing categorization of basic chemical engineering concepts is reasonable, it is clear that we must give a much greater play to the concept of control. However, chemical engineers, like other engineers, are pragmatic individuals. The question of whether a greater play should be given to the control concept depends on whether the play will pay off. The real question is whether the science of control has come of age sufficiently to warrant diligent exploitation by process engineers. Chemical engineering is both a science and an art. In the past the art has sufficed for the solution of process control problems. In order to see how well a scientific approach to the control problem can serve the process industries we must see first of all what is known about the field and then examine the possibilities for applying this knowledge.

Automatic Process Control

Control may be defined as the organization of activity for purpose. Automatic process control is the automatic, rather than manual, regulation of processes. What the purpose of the regulation is requires a little scrutiny. Superficially one would say that the purpose is usually to hold conditions constant at some optimal level. Ideally however the purpose must be the same as the purpose of the parent organization. In the case of an industrial process the purpose must be to maximize the rate of production of profits projected over long enough time spans to ensure protection of the investment which produces the profit. Of course, automatic control working for that purpose would be possible only in a fully automatic plant where every activity is machine controlled. At the present time there are no fully automatic plants, although there are no theoretical reasons why such plants cannot be built.

Control systems regardless of type have a number of features in common. The first feature is that they invariably are made up of sequential arrays of components, frequently disposed in various kinds of closed loops. Since each component in the array can contribute significantly to the behavior of the system, any analysis of the system must consider the behavior of every part of the system as well as all external influences which are brought to bear on the system. That kind of approach to analysis which considers over-all performance from an appraisal of all interacting aspects of components and environment is called a systems approach, and engineering which uses the approach is called systems engineering.

A second characteristic common to all control systems is that they are processors of information. From the standpoint of control neither the size of equipment nor the amount of material and energy flowing in them are of significance in themselves. What is significant is the flow of information around the control loops. Just as one draws a flow sheet to identify important process flows, so can one draw a signal flow diagram to show the flow of information. In the case of process systems the information takes the form of various process variables and the measures of those variables taken by the process instrumentation as electrical, pneumatic, and mechanical signals.

A third characteristic is that most control systems are feedback systems, that is, the signal flow circuits are arranged in closed loops such that output information from the system is fed back to the input. Feedback control systems are usually far less expensive for given performance specifications than are open-loop and feedforward systems. Consider a simple steam-jacketed oil line wherein the outlet oil temperature is to be controlled to some desired temperature by regulating the pressure of the steam in the jacket. The simple way to do the job is to measure the outlet oil temperature, compare this temperature with the desired temperature, and on the basis of the difference between the actual temperature and the desired temperature adjust the steam pressure. By providing the controller with the proper control actions one can make the deviation between actual and desired temperatures as small as required. To do the same job with an open-loop system would require measuring not only the inlet oil temperature and steam pressure, but also the oil flow rate, and in addition would require computation of the effects of the measured variables.

A fourth characteristic of control systems is that the presence of feedback loops in their circuits makes possible instabilities if the signals are reinforced as they go around the loop. This tendency toward instability shows up in periodic excursions of the controlled variables. Since control performance can be evaluated at least in part on the basis of the stability of the control circuit, certain conveniences attach to the use of characterizations of control loop components in terms of their response to periodic forcing.

A fifth and perhaps most important characteristic is that control systems are dynamic systems. It is the dynamic behavior of the system that is the significant measure of performance.

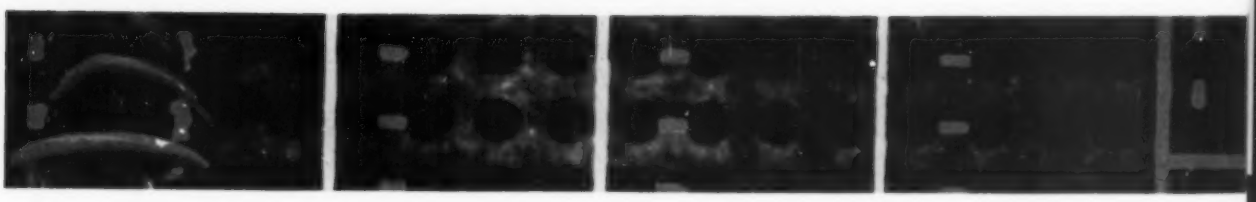
These five characteristics are typical of all control systems whether they are sociological, biological, mechanical, or other, and in principle any formal method of tackling control problems of one kind are equally applicable to other control systems.

CONTROL SYSTEM SYNTHESIS

One can examine what is involved in the solution of control problems generally by considering what is involved in the design of a control system. An *a priori* approach to the problem might go along the following lines:

1. *Set the criteria for system behavior.* For a process control system these criteria might be expressed in terms of the response of particular process variables to certain arbitrary disturbances which correspond to the worst kind of disturbances affecting the operating process.

2. *Choose that combination and arrangement of components in the control loop which will meet the desired criteria of performance at minimal cost.*



The *a priori* approach to this step would be to write equations describing the behavior of each loop component; combine them to a single equation describing the over-all behavior of the whole control system; solve this equation for the arbitrary disturbances used in specifying the desired behavior; compare the solution with the desired behavior; alter component characteristics and rearrange loop sequences as necessary to make the solution of the over-all equation more nearly correspond to the desired behavior; continue in this fashion until the computed behavior matches the preset specification within reasonable design limits.

Unfortunately this approach, though sound in principle, bogs down in practice except for the simplest possible systems because the descriptive equations that result from the general case are nonlinear differential equations which cannot be solved. What is worse, for many process systems one cannot even write the descriptive equations with sufficient reliability to warrant the effort. (And even in those cases where the descriptive equations can be solved there is generally no way of predicting how adjustments in the various loop components will affect the over-all behavior of the system.)

It was perhaps the formidability of this formal mathematical approach to the control system that dissuaded chemical engineers from any creative activity in the field of process control. Rather the chemical engineer concentrated his efforts to good economic advantage on problems related to individual unit operations and process mechanisms without any regard for the integrated dynamic behavior of controlled process systems. He was always reasonably sure that the instrument manufacturers would provide adequate hardware for controlling any process he might devise. Of course, the usual sequence involved in developing an idea into commercial reality has fostered to some extent this notion that all of our chemical engineering processes are readily controllable and pose no real technical problem. The chemist in the laboratory is not likely to spend much time studying reactions which are so unmanageable by conventional techniques that they invariably blow up in his face. Nor are such processes likely ever to emerge from the research laboratory for study in the pilot plant and subsequent development to full-scale production. Yet there is no reason to suppose that such hard-to-control processes can have no commercial value. A more sophisticated view of the control aspect of these processes would lead to methods of controlling them, and certainly for some of them it would be possible to show clear economic justification for their development, even though a disproportionately high investment in control instrumentation would be necessary.

History of Control Engineering

While the chemical engineer contributed nothing to the advance and development of control theory, other engineers have been less disinterested. In particular the electrical engineer and the mechanical engineer have made notable contributions, which although originally made for specific problems within their respective fields, have subsequently been extended to other areas.

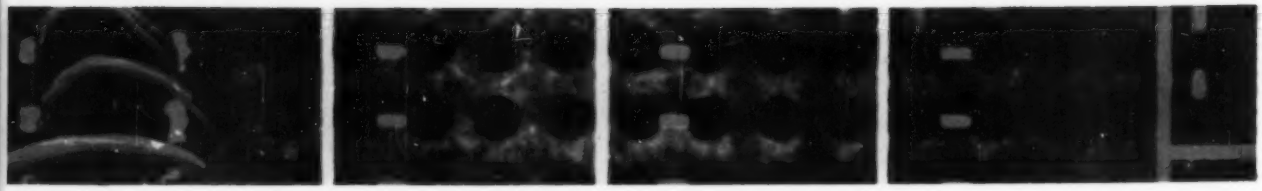
The basic differential equations for closed loop control systems had been studied in some detail as early as the 1920,'s and indeed certain control systems had been designed on the basis of these equations, despite the inherent difficulties of this approach to control system design. A decade later the basis for modern techniques of control system synthesis was set forth inadvertently by Nyquist's analysis of the stability of feedback amplifiers. Frequency response analysis was the powerful tool born out of Nyquist's work, but it was not until World War II forced the development of fire control and related positioning systems that the new tool was put to work. Much of the development was shrouded in wartime secrecy, but immediately following the war there was a flood of publication which has continued down to the present time with many new techniques and applications.

FREQUENCY RESPONSE

Although frequency response techniques were first developed specifically for servomechanisms, they are equally applicable to process control systems. Briefly, the basic technique consists in characterizing each component of the control loops in terms of its respective response to steady-state harmonic forcing. If a sustained sinusoidal variation of a property of an inlet stream to a process unit is imposed long enough for all initial transient effects to die out, there will be a related sinusoidal variation in the corresponding property of a corresponding outlet stream. For most process systems these sinusoids will have the same frequency but will differ in amplitude and the outlet waves will usually lag behind the inlet waves. At different frequencies the amplitude ratios and the phase lags will be different. The amplitude and phase behavior over the frequency spectrum of interest constitute the frequency response characteristics of the particular process unit. If all the components in a series of connected but noninteracting components are linear, the over-all frequency response characteristics will be given by multiplying together the amplitude ratios and adding up the phase angles. Noninteracting components are such components that downstream behavior has no effect on upstream behavior. Linear components are components for which the describing equation is a linear differential equation, that is, one in which all the terms involve the dependent variable and its various derivatives with respect to time to the first power only.

It can be seen now why frequency response is such a useful tool. The effect on the whole system of changing characteristics of a single component or combination of components can be determined directly and quickly without having to resort to tedious trial-and-error solutions of equations. Since it is possible to specify the control criteria for typical systems in terms of frequency response characteristics, it is possible to synthesize control systems reliably without recourse to elaborate mathematical treatment provided the frequency response characteristics of the individual system components are either known or calculable.

Even in the case of systems of interacting nonlinear components these simple frequency response techniques can be made applicable within certain reasonable limitations. There is one source of difficulty which should be mentioned at this point, and that is the fact that many of the empirical rules for specifying desirable control criteria in terms of frequency response characterization are strictly applicable only for so-called minimum phase systems. This limitation in many process cases is a far more stringent one than the limitations regarding linearity and



noninteraction. A minimum phase system is one for which the phase shift is directly relatable to the amplitude ratio, such as occurs for lumped parameter electric circuits. Process systems frequently have in their circuits sizable time delays arising from sampling lags or other distance-velocity lags with the result that the systems are no longer minimum phase. For these systems the empirical rules must be applied with caution or reinterpreted for the particular problem at hand.

Frequency response procedures most usually are handled graphically. Among the more widely used plots are the direct and inverse Nyquist diagrams, which are complex plane polar plots giving the vector loci for amplitude ratio and associated phase angle for all frequencies; the Bode diagram, wherein the logarithm of the amplitude ratio and the numerical value of the phase angle are plotted against the logarithm of the frequency; and the Black-Nichols plot of magnitude ratio vs. phase angle. Perhaps the most generally useful of these plots is the Bode diagram, since it shows clearly the frequency dependence and it admits of the simplest graphical procedures in system synthesis. These procedures include not only the simple graphical addition of the frequency response characteristics but also a simple and rapid sketching in of component characteristics by means of straight-line approximations.

Another advantage of frequency response characterization is that the frequency response characteristics are directly calculable from the descriptive differential equation for a component without requiring a solution of that equation. In cases where the describing equation cannot be written, for example, when the mechanics of the process involved are not understood, the frequency response characteristics must be determined experimentally either directly from sinusoidal forcing or indirectly from fourier analysis of step or pulse forcing or statistical analysis of random forcing.

TRANSIENT RESPONSE

Despite the manipulative advantages of frequency response analysis this approach does not give an immediately understandable picture of what the temporal behavior of a controlled system will be under typical operating conditions. To be sure, the temporal or transient behavior can be inferred by empirical rules and in special cases by direct calculation from the frequency response characteristics, but in general a precise calculation wipes out many of the claimed advantages of convenience and simplicity. Nevertheless it is the transient response to typical system disturbances that is the clearest basis for specifying the criteria of process control system performance. The typical process control situation is that the process variables are being held closely to certain operating points which are most usually fixed or which may be changing slowly with time. How well the process variables are being held constant in the face of disturbances to the system is the simplest measure of the control performance. The step change in an inlet variable is a typical and severe disturbance. Hence an unambiguous and understandable specification of control performance can be made in terms of the transient response of the operating system to a particular step forcing. Fortunately for some simple systems this transient response can be inferred from the frequency response characteristics. For the general case, however, a solution of the descriptive equations for the controlled system must be made.

A powerful technique for attacking control system design by focusing attention on the differential equation for the system, again without attempting a formal solution of the equation, is the root-locus method. This method is particularly useful for minimum-phase systems and as such is not general for process control systems, but it is a handy tool for getting quick insights into the nature of the system equations and by inference into their temporal solutions.

Nonlinear Systems

For nonlinear systems there are no general methods of attack. If there is only one nonlinear component in the loop, the method of describing function analysis may be applicable. This method ignores all frequencies higher than the fundamental in the response of the nonlinear element to sinusoidal forcing on the principle that all higher harmonics will be attenuated in the linear elements in the rest of the loop.

For nonlinear systems which can be treated as second order systems the phase-plane method provides an indication of the transient response of the system via a graphical analysis of a particular second order nonlinear equation.

The availability in recent years of precise, reliable, and relatively inexpensive general-purpose analog computers has opened up many possibilities for treating the problems of control system analysis and synthesis. The principal advantages offered by these instruments are that one can deal directly with solutions of the control system equations and that the effects of adjusting various parameters of the system can be seen quickly. There is no restriction as to the nature of the system equations and nonlinearities can be handled without difficulty. The only requirement is that the equations of the system be known or else that sufficient information be available on the behavior of the system so that a reasonably analogous computer circuit can be devised.

Modern high-speed digital computers also offer great potentialities for control system synthesis and analysis. At the present time both analog and digital computers are available for installation in the control loop itself. Conventional controllers generate their particular control functions by analogy, and there is at least one small-scale general-purpose digital computer on the market for control purposes.

The insertion of computers into the control loop permits optimalization of

AUTOMATIC OPTIMIZATION CONFERENCE. Engineers in the process control field cannot afford to miss the coming conference on automatic process optimization to be held at the University of Delaware, April 2-4, 1958. Host for the conference is ASME's Wilmington section; co-sponsors are AIEE, IRE, ISA and AIChE. For program details see page 146 of this issue.

—AND—

ISA is also sponsoring its 10th Annual Symposium on Control Systems Engineering at the Hotel Essex, Newark, N. J. April 1, 1958. Program and registration information are available from Norman Dayton, Norman Bragar Co., 1060 Broad St., Newark 2, N. J.

process performance and ultimately fully optimalized plant performance.

Problem of Education

On the basis of the foregoing discussion of the nature of automatic process control and some of the techniques for dealing with problems of analysis and design, an appraisal can be made of the problem of chemical engineering education in the field of process control. Historically the teaching of process control in chemical engineering curricula has been confined largely to isolated descriptive courses on the hardware of instrumentation, occasionally with laboratory sessions thrown in to increase the familiarity with the hardware. It has become more apparent in recent years that this kind of approach is needlessly wasteful of the limited time available in the curriculum, and if it is purely descriptive in content is not likely to be of any lasting value to the student.

If it is conceded that chemical engineering fundamentals can be organized in terms of equilibrium, conservation, rate process, and control, then it is clear that we cannot arbitrarily divorce control from the other fundamentals of the field. The basic notions in control theory should be injected early in the curriculum. Much of the ground work necessary to an understanding of the field can well be included with other basic material. For example, unsteady state and transient behavior of processes can be studied as part of the study of the processes themselves, thus developing a familiarity with the differential equations which become of importance in control. Frequency response characterization can be introduced as a tool for determining the properties of materials, for example, thermal conductivities, as well as the key tool for handling control systems. The principles of control can be introduced in the laboratory as well as in the classroom, and in particular the junior laboratory in chemical engineering should not slight the control aspect.

Most chemical engineering curricula today include mathematics through differential equations, and this amount of mathematics is certainly adequate for an understanding of control principles. There is some sentiment for adding another course in mathematics to include more material on operational calculus, function theory, statistics and the like, but it is likely that what is really needed is not more mathematics courses but rather more application of the mathematics in the regular chemical engineering courses. The subject of automatic process control affords an excellent opportunity for practice in applied mathematics.

The major course in control presumably would be given in the senior year either immediately preceding or contemporaneous with the treatment of process economics. It would follow chemical reactor kinetics and the unit operations under whatever guise these subjects might be given. It would be a required course for all students in chemical engineering and it might or might not have an associated laboratory depending on the extent to which the other laboratory courses in the department included material on control theory.

Much might be said about the fact that the subject of control is so broad and draws so heavily on many and diverse disciplines that it has great integrating power in the curriculum. By giving it a special emphasis near the end of the undergraduate curriculum it permits tying up many loose strings while at the same time giving a clearer perspective of the whole of chemical engineering and its relation to other branches of engineering.

Presented at an all-day Symposium on Control Engineering, A.I.Ch.E., New York.

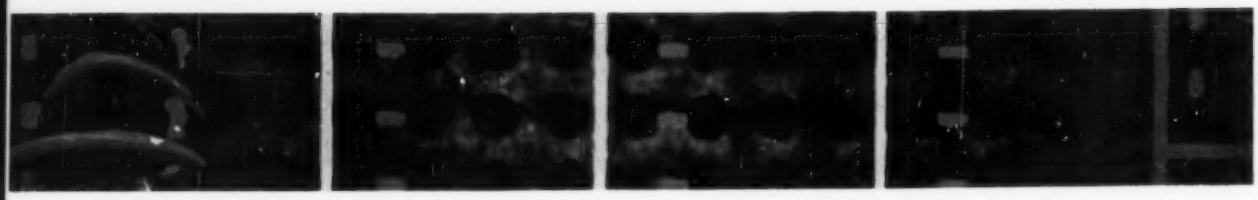
some solutions

Although today's processes are not yet developed to arrive at the optimum combination of process and instrumentation, individual methods are already showing excellent benefits. Techniques for the application of these methods at each step will make possible the optimum plant of the future.

Edward W. James

Engineering Service Division
E. I. du Pont de Nemours & Company, Inc.
Wilmington, Delaware

Systems engineering is no longer new. The degree, however, to which it has been successfully applied in the aircraft and missile fields is far greater than the extent of its use in chemical process development on problems of a surprisingly similar nature.



One can gain insight into the nature and scope of systems engineering from an incident that occurred early in the World War II. In the design of a navigational gyroscope for a new military aircraft also in the design stage, the gyroscope development team requested permission to change the power source from 28 v. d.c. to 400 cycle a.c. This apparently simple request was denied on the following basis: all existing 400-cycle sources in the plane were loaded to capacity. The addition of a next larger size supply would require widening the instrument bay by 1 in. The plane's fuselage was already as near to the propeller tips as permissible. Moving the engines outward would call for a longer wing span. A longer wing span would not permit this plane to land on the class of carrier that could go through the Panama Canal. Therefore, permission to change the power source was not granted.

Whether or not the details of this story are accurate, several conclusions can be drawn from it. First, every system is a part of a bigger system. As soon as particular parts are divided off for individual study and design, the process of systems engineering has already begun, and to achieve the optimum over-all results, this division must be a conscious act. Next, it is seen that important potential interactions exist among the various parts of the system so that changes cannot be made in one part without having their effects on the other parts. Further, it is apparent that there must be means to keep track of these potential interactions; an individual designer cannot know all the effects of his actions. Finally, to produce the tightest design, that is, the one with the least unnecessary slack or leeway, the interactions must be known quantitatively. For instance, how *much* bigger must the instrument bay be made to accommodate the next larger power supply?

It is much simpler to divide a problem into its subproblems for individual solution, and it is certainly general practice. But as processes become more integrated and complex, it is more difficult to decide where to divide them. For example, in the case of a process control system, can the process be properly designed and then instrumented for control in two, almost separate, steps? Consider this extremely simple case:

An exothermic reaction taking place in an agitated tank is cooled with a water jacket. Reactor temperature is sensed with a thermobulb, the signal going to a controller. The controller operates a valve which controls the flow of cooling water to the jacket, and indirectly the flow of heat out of the reaction mass to compensate for the heat of reaction and maintain reaction temperature. Surely the "control" part of this system is separable from the "process" part. There is no question about the thermobulb, the controller, or even the automatic valve. Each represents a major component in the **control** loop. But what about the cooling jacket? What about the reaction volume itself? Can one really say that the heat transfer coefficients, the heat transfer areas, the heat capacity of the catalyst, or the size of the reactor are any less, true components of the control loop? A different coolant velocity would affect the heat transfer rate. A different ratio of reactor volume to heat transfer surface would have a large effect on the control response of this simple loop. Of course, the problem is really much more complicated. These same factors affect reaction rate and yield as well.

Still a deeper question can be raised. Is temperature really the basic control variable or is reaction rate the prime concern? If it is reaction rate, the temperature alone may not be a sufficient measurement. The efficiency of the process and side reactions will be involved. Perhaps better over-all control is achieved in a pipe-line reactor where conditions at various stages in the reaction can be individually controlled, first to start the reaction, next to maintain it at an optimum rate, and finally to quench it quickly to minimize by-product formation. Only in a true continuous reaction like this can we make dynamics really serve our purposes. Today either we slow down our processes by making them continuous batch operations, or we design clever control systems to solve dynamics difficulties encountered because of feedback.

Purpose of Control Systems

The role of control systems engineering is to search out the basic goal of the complete process and to implement that purpose as closely as economically possible, by *using* dynamic action instead of avoiding or suppressing it. In the systems approach, control is not an adjunct to a series of statically designed unit operations, but rather an integral part of process design itself.

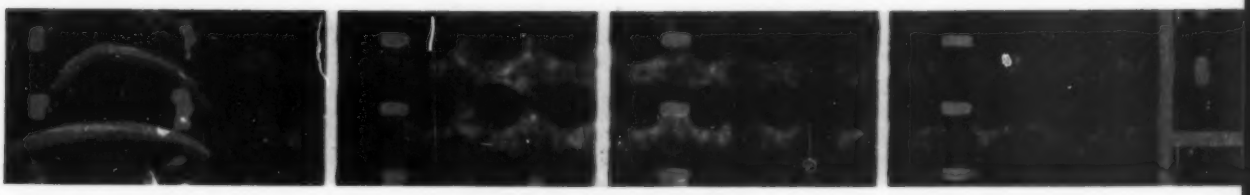
System engineering first appears at the inception of a new process, probably just as a reaction is leaving the chemist's bench and as the first flow sheet is being developed. The chemist himself is assisted in his own investigations by the statistical design of experiments to enable him to get the most basic data with the least number of experiments. Where necessary, regression analysis by digital computer is applied to permit cause-and-effect correlation of empirical data.

During the economic evaluation of various process possibilities, rough analog simulations permit exploration of different flow sheets to determine the optimum from a technical and economic viewpoint. This simulation is based on data taken by the research chemist and is constantly refined during the course of the process development through the use of data developed by the pilot plant and in turn is used to assist in the pilot plant operation. Such a simulation represents the latest operational model on which proposed changes are tested before costly experimentation.

Gathering Automatic Data

To provide the required dynamic and static information quickly and when it is of use, the pilot plant must be equipped with stream analyzers and a portable logging system. The output of the logger must be in a form that can be directly processed by computer, rather than manually, to obtain the required values of process constants and operating conditions. The usual primary purpose of the pilot plant—to produce material for market analysis—is far better served since more operating information is obtained with less disturbance to production, with automatic data gathering.

The joint construction of the pilot plant and the theoretical simulation model lead directly to quantitative static and dynamic specifications for novel equipment and controls perhaps never before conceived, to take *advantage* of the process dynamics. Control systems are actually tested, first on the simulated model and then on the pilot plant, with a general-purpose con-



trol computer available for just this purpose. No less important than the physical plant is the business system which is a part of its operation. The complete system is designed at this point, and, long before it is put to actual use, operability is tested on a simulated model with market changes, seasonal variations, fluctuations in raw material prices, qualities, and deliveries.

During plant construction, training of new operators begins. Again the simulated model is used to demonstrate start-up, shutdown, emergencies, and hazardous operation—experience that could never be gained on the real plant. Mock graphic panels are used whose instruments are driven by the simulated models. Start-up procedures, production rate, and grade changes are all worked out in this way with the personnel who will actually be doing the job.

Relieving Individuals for Other Responsibilities

Data logging equipment designed into the plant begins immediately at start-up to take complete records of plant operation. These data are in a form for computer data processing so that subsequent process improvements in yield, quality, or productivity can be made, based on the results of actual operation. Automatic computer correlation of operating records replaces the present manual method for achieving quality control and final product characteristics. In this way, a plant of minimum investment is produced ready to run with operator intervention and management decision *on exception only*, properly freeing individuals for a higher level of responsibility.

Machine vs. Man

Perhaps this approach sounds more like life in the year 2000, but just what makes it different from what we have been doing for several years ? Just this. Methods of data collection, correlation of data, and routine design are relegated to machine methods. The emphasis is on complete quantitative expression not only of individual reactions, operations, and constants of the system, but also on a more graphic representation of process and control concepts through simulation. Use of automatic methods allows more information to be obtained from the same human effort, thereby at least partially offsetting the higher cost of the deeper approach. If the goal of a minimum capital investment is only partially reached for an optimum operating plant, the incremental costs of a systems engineering job can be returned many times over.

The major problem throughout the process development is to discover mathematical expressions describing as closely as possible the true behavior of the process. No matter how good the theory, experimental verification is essential. By the use of the theory developed by George Box and others, the experimental procedure can be systematized to the point that the fewest possible experiments are made to determine the correlation between factors affecting a product quality for a yield.

With the results of prior experiments to determine the direction of future ones, the complete response picture of a reaction can be mapped to determine the condition for optimum performance. The method is applied in preliminary experimentation or in the investigation of the behavior of a complete plant, either pilot or full-scale.

When theory is inadequate to predict the performance of a pilot plant, large masses of data can be analyzed by regression using large-scale computers to obtain empirical or semiempirical expressions correlating inputs and outputs. The utility of this method ranges from providing basic constants in theoretical expressions to the other extreme of giving an entirely empirical relationship between process conditions and far-removed final product characteristics, like tear strength or dyeability.

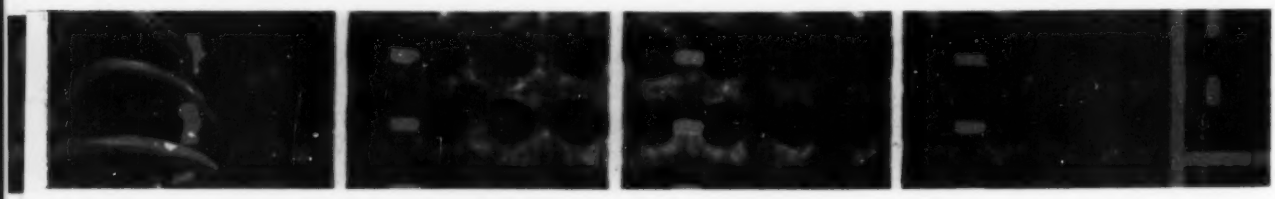
Supplemental methods for determining the dynamic characteristics of components and systems are in use today. Process test equipment and methods provide data for frequency response analysis, which add a knowledge of the unsteady state as well as the static performance of our building blocks. Even automatic correlation means have been tested, notably by James Reswick and Thomas Goodman at MIT. Standard operating data are analyzed by special-purpose computers to provide the dynamics of the process for linear systems, and extension is being made to some nonlinear situations.

Role of Simulation

Simulation of processes and process components by general-purpose analog computers is now generally employed. The complete flexibility of such equipment in handling nonlinearities in large groups of equations is notable. At the same time, such equipment preserves a close relationship between the designer and the problem, allowing him to investigate entirely novel schemes very quickly and to observe the effects of any changes on the complete system. In the way that physical models are used to visualize the final plant during design, the simulation represents an operational model used to visualize the concepts of the operation all during the design.

The method that must be used to obtain data at the pilot plant stage is being tested and refined in the present process logging systems. Problems in scanning, compatibility of elements, reliability, output equipment, and media are being studied, and solutions are being developed. Ultimately smaller portable units will collect large quantities of data on tape for direct computer procesing. Already in one du Pont laboratory physiological data are being recorded on magnetic tape and are processed by analog computer elements to determine correlations. Certainly chemical processes are no more complex than the human body.

A large number of control systems, almost unknown in the chemical industry, have been developed and some used in aircraft and missile guidance. For example, terminal control is used in automatic landing systems. Here the optimum path may change at each instant, only the final touchdown being of importance. Work at Case Institute by Don Eckman and Irving Lefkowitz on a computer-controlled hydrogenation has shown the applicability to chemical processing. Two-mode control has been developed, in which only full or zero driving force is applied, the switchover point for optimum response being determined by a computer.



Multivariable control has been used in several applications where there are internal process interactions, for example, jet engine control by Aaron Boksenbom at NACA. Here, each valve is actuated by signals from not one, but several process measurements, the purpose being to keep the control action in one part of the system from disturbing other parts unnecessarily. Sampled-data systems have been well investigated by John Raggazini and others, and will be used where computer control dictates time-sharing of facilities. Optimizing systems automatically search for and control to an optimum. The Case Institute work was also an example of continuous optimizing control. Self-adaptive systems, first investigated by Ross Ashby in England, have been interpreted for control purposes by Charles Taylor of Daystrom and others. The ability of a system to control itself for disturbances not intended by the designer sounds like black magic, but appears feasible in many cases.

These schemes are all a long way from the familiar proportional band, reset and derivative controllers we now use. Before they can be installed with confidence that they will provide benefits to cover their cost, they must be tested. Already jet engine controls, synthesized from theory, have been tested by a general-purpose analog computer as a real-time controller. This practice on a pilot plant will not only permit new methods to be tried, but actually will provide smoother pilot plant operation.

Design and Computers

Use of computers is becoming established in the routine design of process equipment such as heat exchangers, columns, and even some reactors. This practice is to be encouraged, as long as we do not cease to explore novel possibilities. The analog computer has been used in equipment design for just this purpose of searching out new methods for obtaining better control. Much cheaper than the experimental method, it permits evaluation of many alternative approaches, thus saving critical time and considerable cost.

Mock-ups for training purposes were widely employed during the war for quick training of raw personnel in dangerous and complex activities. More and more complete training models are being built for process operators prior to start-up. The original pictorial facsimile of control panels and process diagrams are being replaced with extremely realistic mock panels complete with simulated instruments. The next step will be to drive these instruments from the analog simulation to give the exact effect that the operator will experience during start-up. Training of this sort improves the safety of a start-up immeasurably, in addition to contributing to its earlier achievement.

When the ultimate in advanced control is provided by the computing-controller, sufficient information will probably be known about the process performance to allow start-up and shutdown by computer tape. This method is right now programming missile flights and tests, and controlling huge machine tools to thousandths of an inch.

Application of process control methods to the all-important business phases of plant operation is long overdue. Several years before his untimely death, Don Campbell at MIT began writing about these possibilities, and others have contributed since that time. In spite of the large effort in Operations Research on business control problems, we have seen few real applications of dynamics principles to the flow of business data. Nevertheless, this problem is little more difficult than the process problem and for a true control engineering job should be treated at the design stage of the plant. Simulations and exploration of alternatives can permit the design of a system that will leave the future plant management proper time for higher decisions and the attention to personned that it is hoped no computer will ever be able to handle.

Process Logger

There are several things that are likely to happen after the start-up in operation of a successful plant. First, improvements in quality or yield may be required even in this gleaming plant of the future. More likely, additional production or a duplicate plant may be required. Today, in spite of the continuous round of experiments that are being conducted every day in the operation of a plant, the results that might be used to do a better job in process improvement or enlargement are effectively being thrown away. Of course, records are kept, but they are inaccurate, incomplete, and worst of all, in such a form that only man-months of effort can get useful information from them. The process logger is a first step in the evolution of a reliable data collecting device that would produce records in a form for automatic machine correlation. Large computers fed with records of daily operation, properly edited and interpreted, would search out the underlying mechanisms, limitations, and possibilities in these going plants. The constants required for quantitative designs would be determined and made available for future use.

Application of Methods

An effort has been made in this article to show that the individual techniques of control engineering are *already* in successful use in the chemical industry with the possible exception of the over-all systems look. To achieve the potential benefits, it is now a matter of applying the methods at the proper time and place on a systematic basis. But half-use is not enough. There is a certain threshold of activity that must be undertaken to obtain any benefits at all. Evaluation of the possibilities cannot be done in terms of our present framework. The reduction of one operator per shift by the addition of a logging system, the improvement of yield by 1 per cent, the reduction of design time for a heat exchanger—all these are minor compared with the possibilities of reducing capital investment by perhaps 50 per cent or operating a process profitably, that could never have been operated at all before. One must realize that the heart of what is called automation is not a super-mechanization of present-day systems with present-day controls, but rather that it is a complete rethinking of the operation from top to bottom to find a hybrid and inseparable combination of controls and process that best serves the over-all goal.

Presented at all-day Symposium on Control Engineering, A.I.Ch.E. meeting, New York.

technology of

BORON HYDRIDES

Although known in the laboratory for forty years, boron hydrides are now coming into importance under the impetus of high calorie jet fuel requirements.

Coleman J. Major

American Potash & Chemical Corporation, Henderson, Nevada

The boron hydrides may be conveniently divided into two separate groups having the general formulas, B_nH_{n+4} and B_nH_{n+6}. Members of the first group are considered relatively stable, whereas compounds of the second group exhibit considerable thermal instability. The principal compounds thus far characterized are listed in Table 1.

Diborane, the lowest member of the series, is a gas at ordinary conditions. Decaborane, the highest member of the series, is a solid, and all the other compounds are liquids under normal conditions.

Evidence of the existence of other boron hydrides has been indicated, but these compounds exhibit only transitory or rare existence and are not considered of any practical importance at present. Various polymeric hydrides having the arbitrary formula $(BH_n)_x$ appear to exist in several forms, in which n may vary from 0.8 to 1.5 (*1*) and x is a variable. They are solid or liquid nonvolatile compounds and are usually produced by degradation of some of the volatile boron hydrides.

The structural formulas for five of the well-known hydrides are presented in Figures 1 to 5. It should be noted that the bonds shown in these figures are not the usual covalent bonds found in organic compounds, but represent a "community sharing" of electrons since the compounds are electron-deficient.

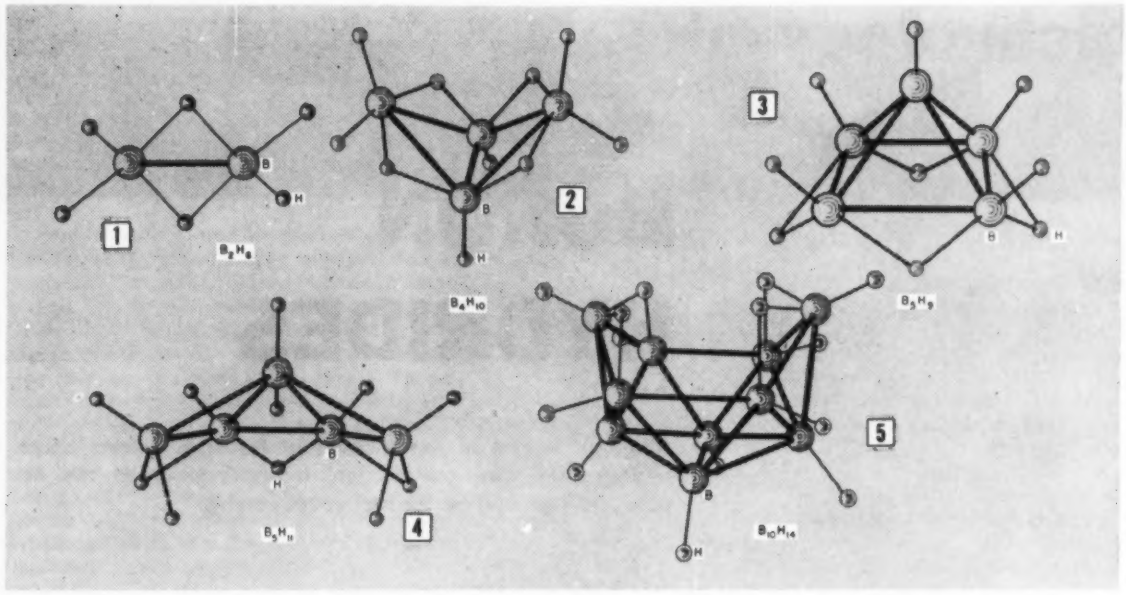
The first really intensive study of the preparation and identification of the boron hydrides was undertaken in Germany by Alfred Stock and his coworkers. In 1912 Stock and Massenez (*2*) reported the preparation and identification of tetraborane (B_4H_{10}), the first boron hydride to be definitely characterized as an individual compound. By 1924 Stock and his colleagues had prepared and identified all of the other presently known hydrides; B_2H_6, B_5H_9, B_6H_{10}, $B_{10}H_{14}$, and B_5H_{11}.

Activities in the field of boron hydrides in the United States were reported in 1931 by Schlesinger and Burg (*3*) when they described the first direct preparation of diborane by passing a mixture of boron trichloride and hydrogen through an electric discharge at low pressure. Conversions of boron trichloride to boron hydride were as high as 30%/pass and over-all yields reached 75%. A later improvement by Stock and Sütterlin (*4*) increased the over-all yield to 80% by the use of boron tribromide instead of the chloride. A further improvement was patented in 1951 by Schlesinger and Brown (*5*). (See Table 5.)

Early in 1941 Schlesinger and his coworkers undertook to synthesize new volatile compounds of uranium. In the course of their work they were able to produce three new volatile compounds, uranium (IV) borohydride and two of its methyl derivatives. In addition to the actual preparation of these borohydrides, they also investigated methods for the preparation of the raw materials and intermediates used in their reactions. They were successful in developing methods for producing borohydrides of various metals and they also were able to demonstrate that once a source of metal borohydrides was made available, much simpler processes for producing diborane could be utilized than were possible by either the boride-acid or the electrical discharge process. They showed that diborane could be produced by reacting a borohydride with an acid that is stronger than diborane. This discovery opened up a whole new frontier for the study of the boron hydrides on a scale that was hitherto impractical.

Following World War II, intensive research and development of jets and rockets in the guided missile field were initiated both by the United States and the Soviet Union. Because of the speed and range requirements of these vehicles, it was obvious that the conventional fuels had serious limitations as far as energy content was concerned. Owing to their high heats of combustion, attention was focused on the boron hydrides and their derivatives. A comparison of the heating values of the boron hydrides and hydrogen with the conventional jet fuel, JP-4, is given in Figure 6.

That the boron hydrides and derivatives now figure heavily in the missiles program is evident from recent announcements of the operation and proposed construction of several high en-



Figs. 1-5. 1. Diborane; 2. Tetraborane; 3. Pentaborane-9; 4. Pentaborane-11; 5. Decaborane.

Table 1.

B_nH_{n+4}			B_nH_{n+6}		
Formula	Name	Normal State	Formula	Name	Normal State
B_2H_6	Diborane	gas	B_4H_{10}	Tetraborane	liquid
B_5H_9	Pentaborane *	liquid	B_5H_{11}	Unstable Pentaborane **	liquid
B_6H_{10}	Hexaborane	liquid			
$B_{10}H_{14}$	Decaborane	solid			

* Also known as stable pentaborane or pentaborane-9.
** Also known as pentaborane-11 or dihydropentaborane.

TABLE 4.—Vapor Pressure Equations*

Compound	Equation	Equation applicable in range	Literature cited
B_2H_6 (liquid)	$\log p = 7.185 - \frac{782.8}{T}$	−38° to +17° C.	(13)
	$\log p = 8.1110 - \frac{870.95}{T} - 0.00221T$	−161° to −97° C.	(18)
	$\log p = 8.1251 - \frac{870.68}{T} - 0.002339T$	−95° to +15° C.	(19)
B_5H_9 (liquid)	$\log p = 7.8455 - \frac{1646.3}{T}$	0° to 58.4° C.	(20)
B_5H_{11} (liquid)	$\log p = 7.901 - \frac{1690.3}{T}$		(15)
$B_{10}H_{14}$ (liquid)	$\log p = 8.3647 - \frac{2642}{T}$	99.5° to 122° C.	(21)
$B_{10}H_{14}$ (solid)	$\log p = 10.3822 - \frac{3392}{T}$	72° to 99° C.	(21)

See Figures 7, 8, 9.
*p = vapor pressure, mm. Hg, abs.
T = absolute temperature, °K.

Table 2.—Stabilities of Some Boron Hydrides

$B_{10}H_{14}$ Very stable. Can be heated for considerable periods at 150° C. Noticeable decomposition at 170° C.
B_5H_9 Stable for years at room temperature. Decomposes slowly at 150° C.
B_2H_6 Fairly stable. About 10% decomposition per year in presence of hydrogen.
B_6H_{10} Decomposes slowly.
B_4H_{10} Fairly rapid decomposition.
B_5H_{11} Begins to decompose within an hour.

In the presence of air at room temperature stabilities are:

$B_{10}H_{14}$ Very stable. Not spontaneously flammable. Will explode in oxygen at 100° C.
B_6H_{10} Quite stable. Not spontaneously flammable.
B_4H_{10} Not spontaneously flammable if pure.
B_5H_9 Has been variously reported as both spontaneously flammable and not flammable. Probably, self-ignition is due to small impurities.
B_5H_{11} Spontaneously flammable.
B_2H_6 Spontaneously flammable.

In the presence of water the stabilities vary over a wide range as indicated:

$B_{10}H_{14}$ Hydrolyzes very slowly at room temperature.
$\left(\begin{matrix}B_6H_{10}\\B_5H_9\end{matrix}\right)$ Can be hydrolyzed completely only at elevated temperatures.
B_4H_{10} Will hydrolyze completely within 24 hr. at room temperature.
B_5H_{11} Rapid hydrolysis. Will hydrolyze very rapidly in acid solutions.
B_2H_6 Hydrolyzes almost instantaneously at room temperature.

In all these cases, the final products of the hydrolysis are boric acid and hydrogen.

ergy fuel plants. Callery Chemical Company is building a $38 million plant for the Navy at Muskogee, Oklahoma, and a smaller, privately financed plant at Lawrence, Kansas. Olin Mathieson Chemical Corporation has completed a company-owned $5.5 million plant at Niagara Falls and is building a $4.5 million plant for the Navy and a $36 million plant for the Air Force at Model City, New York. American Potash & Chemical Corporation started production of decaborane in its company-owned pilot plant last year.

In 1955 the annual budget for the U. S. Department of Defense for the procurement, research, and development of missiles approached a billion dollars. For the fiscal year, 1958, expenditures will probably exceed two billion dollars, of which perhaps one hundred million dollars will be spent for the fuels portion of these vehicles. It has been estimated (*6*) that high energy fuels will be a billion-dollar-a-year industry ten years from now. The chemical industry, therefore, stands at the threshold of a new huge and challenging assignment of supplying the skyrocketing market for chemicals to propel our jets and rockets of tomorrow.

No attempt is made here to present all of the available data on the physical and chemical properties of the boron hydrides. A few of the more important physical properties are presented in Table 3. Vapor pressure equations are presented in Table 4 and vapor pressure curves are given in Figures 7, 8, and 9. Liquid densities for diborane and pentaborane are shown in Figure 10.

At room temperature in the absence of oxygen the relative stabilities of the various boron hydrides are shown in Table 2.

When the boron hydrides are burned, they form boric oxide and water. They react with amines. With ammonia they form complexes. Alcohols react with the boron hydrides to form alkoxyborines. The action of methanol on diborane illustrates the types of products obtained.

$B_2H_6 + 6CH_3OH \rightarrow 6H_2 + 2B(OCH_3)_3$
(Methyl borate or trimethoxyborine)
$B_2H_6 + 4CH_3OH \rightarrow 5H_2 + 2BH(OCH_3)_2$
(Dimethoxyborine)*

Diborane reacts with trialkylborines to form a mixture of mono-, di-, tri-, and tetralkyl diboranes. Typical reactions are illustrated below:

$5B_2H_6 + 2B(CH_3)_3 \leftrightarrows 6B_2H_5CH_3$
(monomethyldiborane)
$2B_2H_6 + 2B(CH_3)_3 \leftrightarrows 3B_2H_4(CH_3)_2$
(dimethyldiborane)
$B_2H_6 + 2B(CH_3)_3 \leftrightarrows 2B_2H_3(CH_3)_3$
(trimethyldiborane)
$B_2H_6 + 4B(CH_3)_3 \leftrightarrows 3B_2H_2(CH_3)_4$
(tetramethyldiborane)

It is of interest to note that alkylated diboranes containing more than four alkyl groups are not formed.

Chlorine reacts violently with diborane, tetraborane, and pentaborane at room temperature to form boron trichloride and hydrogen chloride. Chlorinated boranes are formed at low temperatures. For example, at −80° C., pentaborane reacts to form monochloro- and some dichloropentaborane as follows:

$B_5H_9 + Cl_2 \rightarrow B_5H_8Cl + HCl$
$B_5H_9 + 2Cl_2 \rightarrow B_5H_7Cl_2 + 2HCl$

Decaborane reacts very slowly with chlorine at room temperature, the principal products being monochloro- and dichlorodecaborane.

Hydrogen chloride reacts slowly with diborane and tetraborane to form chlorinated boranes but does not react with pentaborane or decaborane.

Methods of Preparation

Diborane may be used as the starting material for the preparation of nearly all of the other boron hydrides. Therefore, greatest attention is focused on the preparation of diborane itself. The known methods may be broken down into a number of different general routes outlined as follows:

* Decomposes reversibly into diborane and methyl borate.

TABLE 3.—Properties of the Boron Hydrides

	Diborane	Tetraborane	Pentaborane	Unstable Pentaborane	Hexaborane	Decaborane
Molecular formula	B_2H_6	B_4H_{10}	B_5H_9	B_5H_{11}	B_6H_{10}	$B_{10}H_{14}$
Molecular weight	27.69	53.36	63.17	65.19	75.00	122.31
Normal state	Gas	Liquid	Liquid	Liquid	Liquid	Solid
Stability	Relatively stable	Unstable	Stable	Unstable	Slightly unstable	Stable
Melting point, ° C.	−165.5	−120	−46.6	−123	−65	98.8 (16) 99.5 (17) 99.7 (11)
Boiling point, ° C.	−92.5	17.6-18.0 (11)	58.4	65 (11)	7.2 mm. at 0° C.	213 extrap.
Density of liquid	0.447 at −112° C. (10)	0.59 at −70° C. (11) 0.56 at −35° C. (10)	0.61 at 0° C. (10) 0.63 at 16° C. (13)		0.69 at 0° C. (10)	0.78 at 100° C. (10)
Density of solid	0.557 at −183° C. (10)					0.94 at 25° C. (1)
Heating value, B.t.u./lb. low high	31,200 33,300	30,300 32,100	29,000 30,400	29,800 31,400	28,800 30,100	28,200 29,300
Heat of formation, kcal./mole	7.53 (gas)		7.72 (liquid)			8 (solid)
Heat of fusion, B.t.u./lb.	69 (11a) at m.p.		40.5 (14) at m.p.			77 (16)
Heat of sublimation, B.t.u./lb.						248
Heat of vaporization, B.t.u./lb.	224 (1) at b.p.	218 (12) at b.p.	212 (1) at b.p.	214 (15) at b.p.		171 (1)

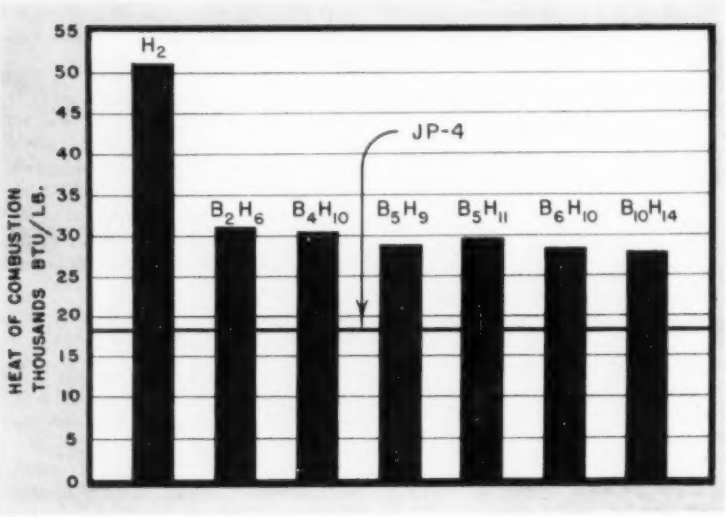


Fig. 6. Heats of combustion.

1. *Thermal decomposition of a boron hydride*
2. *Decomposition of a metal borohydride*
   a. *With a mineral acid*
   b. *With* CO_2
   c. *With* $AgClO_4$
   d. *With CuCl*
3. *Reduction of a metal borofluoride*
   a. *With a metal hydride*
   b. *With a metal borohydride*
4. *Reduction of a boron halide*
   a. *With hydrogen*
   b. *With hydrogen and an active metal*
   c. *With a metal hydride*
   d. *With a metal borohydride*
   e. *With a metal alkoxyborohydride*

The interconversion of the various boron hydrides is illustrated in Figure 11. Thus, diborane may be converted into pentaborane-11 by heating to 115-120° C. It should be emphasized that none of these conversions is a clean-cut reaction; other boron hydrides are also formed. For example, when diborane is heated to 115° C., the reaction products contain predominantly B_5H_{11} with some quantities of B_5H_9, $B_{10}H_{14}$ and traces of B_4H_{10}.

Toxicity

The American Conference of Governmental Industrial Hygienists (*7*) presents the following recommended values for the maximum average atmospheric concentration to which humans may be exposed for an eight-hour working day without injury to health:

Diborane	0.1 p.p.m.
Pentaborane	0.01 (tentative)
Decaborane	0.05 (tentative)
Hydrogen Cyanide	10
Phosgene	1

Values for hydrogen cyanide and phosgene are presented here merely for comparative purposes. Thus, according to these figures, diborane may be considered to be ten times as toxic as phosgene and a hundred times as toxic as hydrogen cyanide.

The median detectable concentrations by odor by humans for the three

Fig. 7. Vapor pressure of diborane.

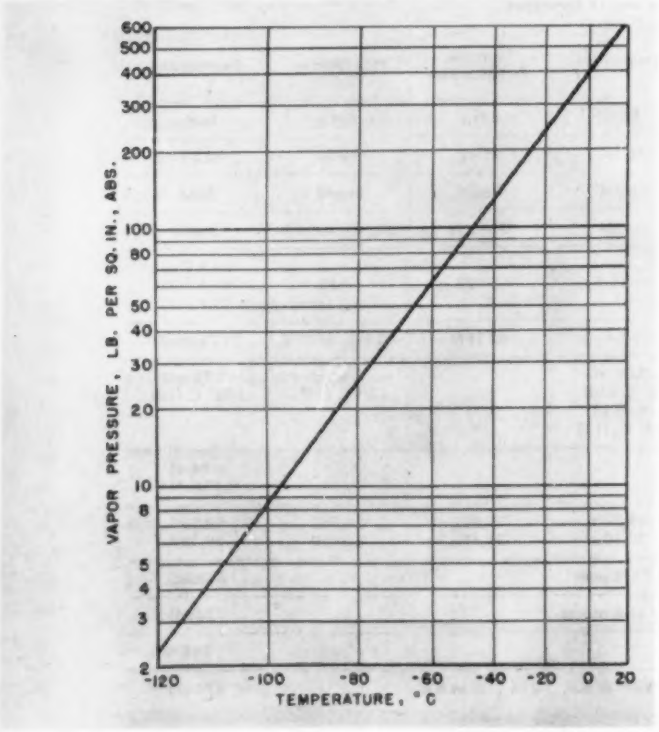
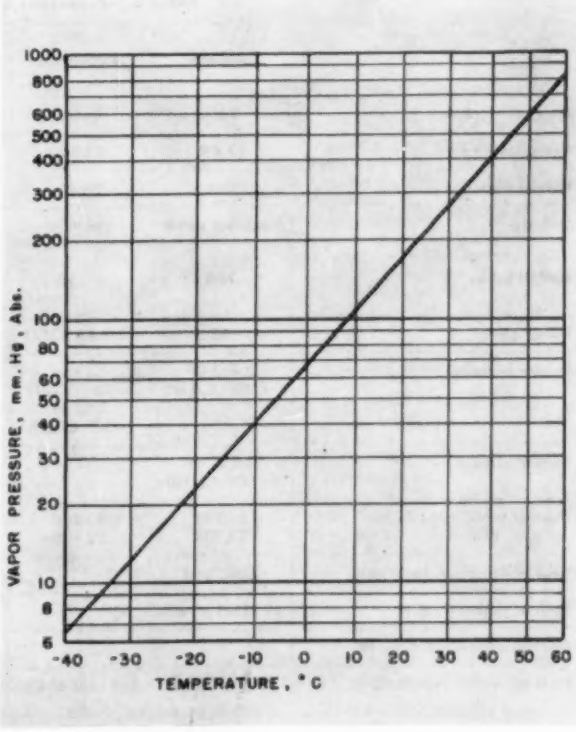


Fig. 8. Vapor pressure of pentaborane-9.



principal boron hydrides have been reported (*8*) as follows:

Diborane	1.6 to 3.2 p.p.m. (avg. 2.4)
Pentaborane-9	0.9
Decaborane	0.05

It may, therefore, be concluded that the sense of smell should not be relied upon for detecting toxic concentrations of diborane or pentaborane but that decaborane can be detected in concentrations near the toxic level.

Emergency protection (*9*) against inhalation of diborane may be obtained by using a chemical cartridge respirator containing active Hopcalite. Cartridges of activated carbon are slightly less effective. For pentaborane, activated carbon is most effective, and for decaborane, silica gel is the best cartridge material. Activated carbon has been used with success for decaborane but is not considered quite as effective as silica gel.

Materials of Construction

The boron hydrides are relatively noncorrosive toward most of the common materials of construction. Diborane has been handled in steel, stainless steel, brass, copper, lead, Teflon, Tygon, and Kel-F equipment and parts at normal temperatures. At extremely low temperatures (−50° C. and below), metals such as 18-8 stainless

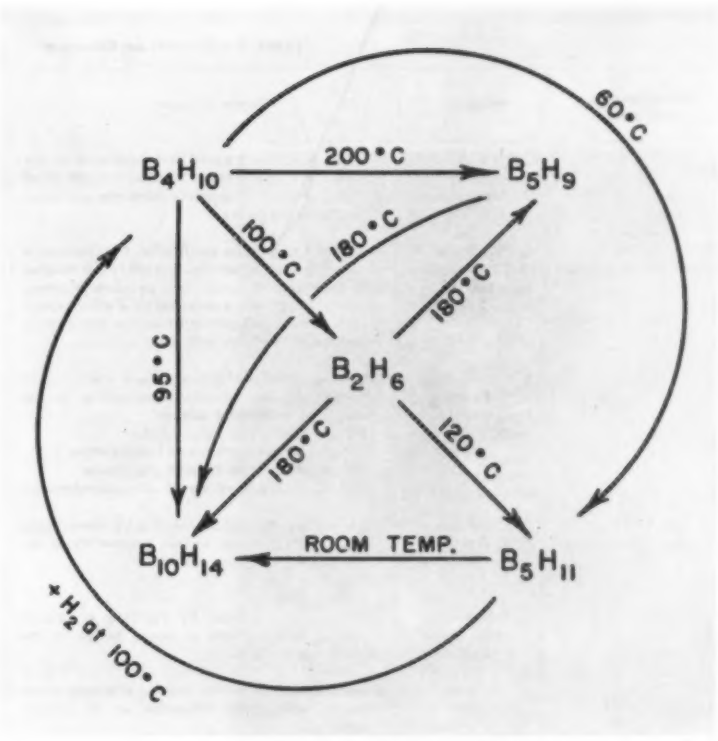


Fig. 11. Interconversion of the boron hydrides.

Fig. 9. Vapor pressure of decaborane.

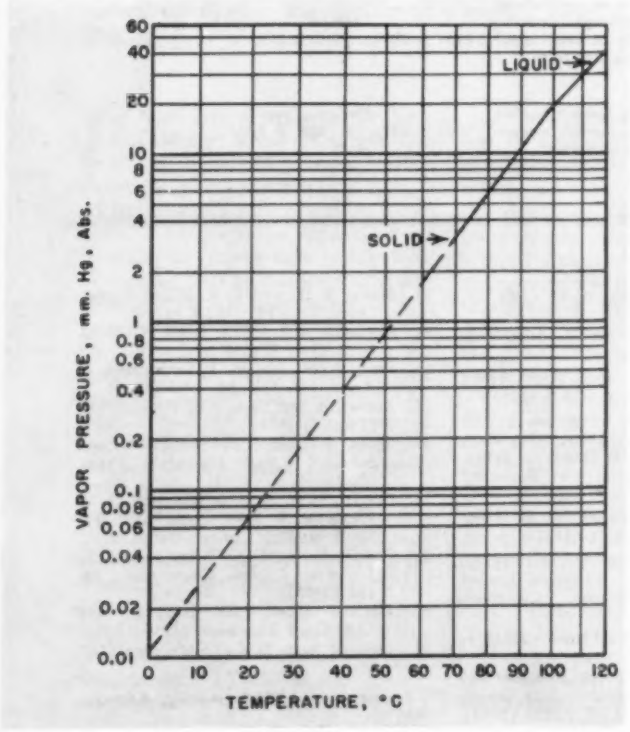


Fig. 10. Liquid density.

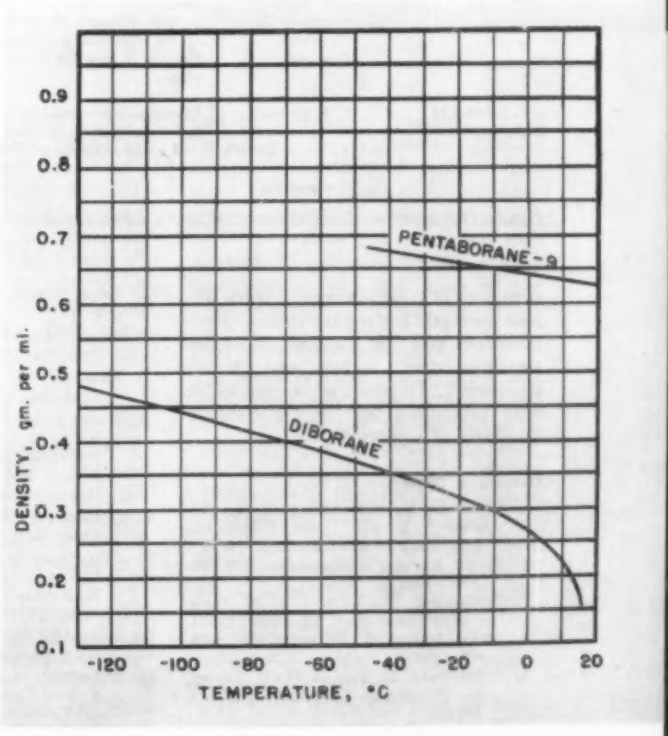


TABLE 5.—Patents on Diborane

Patent number and date	Inventor	Scope of patent	Typical reactions
U.S. 2,469,879 (May 10, 1949).	D. T. Hurd Assignee: General Electric Company	A boron halide is treated with hydrogen in the presence of an alkali metal or alkaline earth metal at 200 to 400° C. to produce diborane and other higher boron hydrides.	$2BCl_3 + 3H_2 + 3Mg \rightarrow 3MgCl_2 + B_2H_6$
U.S. 2,533,696 (December 12, 1950).	G. W. Schaeffer G. D. Barbaras Assignee: U.S.A. (A.E.C.)	This patent covers the purification of diborane in which ethane is an impurity. The mixture is treated with a pyridine to produce a pyridine-diborane complex. The ethane is removed by distillation and the diborane is regenerated from the complex by treatment of the latter with a boron halide.	$2C_5H_5N + B_2H_6 \rightarrow 2(C_5H_5N \cdot BH_3)$ $2(C_5H_5N \cdot BH_3) + 2BF_3 \rightarrow B_2H_6 + 2C_5H_5N \cdot BF_3$
U.S. 2,543,511 (February 27, 1951).	H. I. Schlesinger H. C. Brown Assignee: U.S.A. (A.E.C.)	Diborane is produced by reacting a boron halide with one of the following, preferably in the presence of an organic solvent: (1) an alkali metal borohydride (2) an alkaline earth metal borohydride (3) an alkali metal alkoxyborohydride (4) an alkaline earth metal alkoxyborohydride	$3NaBH_4 + 4(BF_3 \cdot Et_2O) \rightarrow 3NaBF_4 + 2B_2H_6 + 4Et_2O$ $6NaBH(OCH_3)_3 + 8(BF_3 \cdot Et_2O) \rightarrow 6B(OCH_3)_3 + 6NaBF_4 + B_2H_6 + 8Et_2O$
U.S. 2,544,472 (March 6, 1951).	H. I. Schlesinger H. C. Brown Assignee: U.S.A. (A.E.C.)	Diborane is produced by reacting an alkali metal hydride with a boron halide, preferably in the presence of an organic solvent.	$6NaH + 2BF_3 \rightarrow B_2H_6 + NaF$ $6NaH + 8BF_3 \rightarrow B_2H_6 + 6NaBF_4$
U.S. 2,550,985 (May 1, 1951).	A. E. Finholt Assignee: Metal Hydrides, Inc.	Diborane is produced by reacting a calcium aluminum hydride with a boron halide in the presence of dioxane.	$3Ca(AlH_4)_2 + 8BF_3 \rightarrow 3CaF_2 + 6AlF_3 + 4B_2H_6$ $3Ca(AlH_4)_2 + 14BF_3 \rightarrow 3Ca(BF_4)_2 + 6AlF_3 + 4B_2H_6$
U.S. 2,711,946 (June 28, 1955).	W. H. Schechter Zelienople S. L. Walters Assignee: Callery Chemical Company	Diborane is prepared by reacting diborane diammoniate with boron trifluoride or its organic complexes.	$B_2H_6 \cdot 2NH_3 + 2(BF_3 \cdot Et_2O) \rightarrow B_2H_6 + 2(BF_3 \cdot NH_3) + 2Et_2O$
U.S. 2,737,447 (March 6, 1956).	J. R. Elliott Assignee: General Electric Company	Diborane is produced by reacting lithium hydride and a boron halide in the presence of the tetrahydrofuran solvent.	$6LiH + 2BF_3 \xrightarrow{THF} 6LiF + B_2H_6$
U.S. 2,796,328 (June 18, 1957).	C. B. Jackson R. M. Bovard J. R. Taylor Assignee: Callery Chemical Company	Diborane is produced by a two-stage process. In the first stage, an alkali metal borohydride is reacted with boron trifluoride in an inert solvent to form diborane. In the second stage, a portion of the diborane is reacted with an alkali metal hydride to form the borohydride used in the first stage.	$6LiBH_4 + 2BF_3 \xrightarrow{Solvent} 4B_2H_6 + 6LiF$ $6LiH + 3B_2H_6 \xrightarrow{Solvent} 6LiBH_4$
U.S. 2,796,329 (June 18, 1957).	C. B. Jackson R. M. Bovard Assignee: Callery Chemical Company	Diborane is produced by adding boron trifluoride to lithium hydride in ether as a reaction medium and in the presence of $LiBH_4$ as a catalyst.	$6LiH + 2BF_3 \xrightarrow[Et_2O]{LiBH_4} 6LiF + B_2H_6$

steel with a good low temperature impact strength are recommended. Pentaborane may be handled in steel, stainless steel, nickel, and Monel equipment. Decaborane is compatible with practically any of the common materials of construction.

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Presented at A.I.Ch.E. meeting, Baltimore, Md.

REPORT ON PILOT PLANT SYNTHESIS OF LIQUID FUELS

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Practicability of synthesis of liquid fuels from carbon monoxide and hydrogen by use of iron nitride and cobalt catalysts is the subject of the pilot plant studies discussed in the accompanying article.

Fig. 2. Bench-scale fluid unit (2-liter capacity).

The feasibility of applying the fluidized catalyst technique to the synthesis of liquid fuels from carbon monoxide and hydrogen has been a subject of much controversy in recent years. This process is remarkable for its ability to remove heat rapidly from the reactor, and by maintaining a uniform catalyst bed temperature, a high space velocity yield can be realized. On the other hand, several serious drawbacks have become evident ever since the process was developed (*1*). Thus defluidization frequently occurs as a result of accumulation of heavy products on the surfaces of catalysts when the process is operated at low temperatures, while a high reaction temperature would induce rapid carbon deposition with consequent deterioration of the catalyst and "blow-over." The poor stability of ordinary fused or sintered iron catalyst makes the task of choosing satisfactory operating conditions a difficult one.

Anderson and his coworkers (*2*) claim several distinct merits for the use of iron nitrides as catalysts in gas synthesis, the most important of which are their resistance to carbon deposition and their greater mechanical strength. Also the low-molecular-weight product from such catalysts is an advantage to be utilized in fluidized reactors at relatively low temperatures. Anderson recommended their use in the fluidized synthesis on these grounds.

Process research on synthetic liquid fuels has been in progress at the Institute of Petroleum, Academia Sinica, China, since 1950. At first, the work dealt chiefly with precipitated iron catalysts (*18*). During the past three years, however, efforts have been directed toward the development of a fluidized process using nitrided catalysts. This work has included (1) catalysts testing in fixed-bed units of 7-30 ml. capacity, (2) bench-scale, and (3) pilot plant studies (capacity: 2 and 30 liters catalyst respectively) as well as analyses of products. With the aim of improving selectivity of the catalyst, the effects of process variables, catalyst composition, and mode of preparation have been studied. A brief summary of pilot plant data thus obtained is presented below. Finally some results from the study on the cobalt catalyst are also reported.

Study of Iron Catalysts

A nitrided fused-iron catalyst was tested at normal pressure, and it did not show any drop in activity in a 3-week interval. However, the selectivity was poor and the space velocity could hardly be raised above 200 liters of synthesized gas (S.T.P.) per liter of catalyst per hour in order to obtain a high feed gas conversion. Tests at 7-20 atm. gave constant CO conversions higher than 90% at space velocities above 1,000 for more than 2 months with a distribution of essentially stable products (*3*).

The effect of particle size on cata-

lyst performance became very marked at high throughputs. In contrast to the constant activity of 80-200 mesh samples at high space velocities, the 5-6 mesh granules showed sharp decline in activity with time.

In order to suppress excessive carbon dioxide formation during synthesis, the effect of process variables were studied rather extensively (*4, 5*). It was found that the reaction pressure and recycle ratio were the most significant factors, while temperature and space velocity played less important roles. The following expression was found to exist between the partial pressures of the components in exit gases:

$$\frac{P_{CO_2} P_{H_2}}{P^n_{CO} P_{H_2O}} = C \qquad (1)$$

where n and C are constants under a given set of process conditions. With a H_2/CO feed ratio around 1.25, the loss in yield of hydrocarbons can be limited to within 8 g./std. cu.cm. ($CO + H_2$), if the pressure P (in atm.) and recycle ratio R are chosen to conform to the following expression

$$P^{0.74}(R + 0.5) = 34 \qquad (2)$$

It can be shown that Equation (2) is an immediate consequence of Equation (1), when suitable numerical values are substituted for the parameters.

The effect of catalyst composition on selectivity was investigated. As the N/Fe atom ratio was lowered, a decrease of 17 g./cu.m. ($CO + H_2$) of $CH_4 + C_2H_6$ yield was observed in the 1½-in. fluid unit. The corresponding gain in C_3^+ yield was, however, obtained only with difficulty in operation. Different ways of alkali addition were compared and impregnation with a solution of potassium carbonate appeared to be the most promising (*6*). A yield of methane 10 g./cu.m. ($CO + H_2$) in fixed-bed unit and 15 g./cu.m. ($CO + H_2$) in the small fluid reactor was found. A comparison of the activity of the alkalized catalyst and the normally nitrided ones may be found in Table 2. It was noted that although for different catalysts a shift of product distribution always accompanied the curtailment of methane formation, the two were not necessarily related by any unique function. From the data obtained in the small fluid unit, it was also concluded that the relative amounts of C_{3-4}, C_{5-11} and C_{12} fractions did not conform to the distribution rule given by Manes (*7*):

$$W_r^+/W_3^+ = \alpha^{r-3}\left[\frac{r - \alpha(r-1)}{3 - 2\alpha}\right] \qquad (3)$$

where constant chain growth probability is assumed. In Equation (3), r = number of carbon atoms per molecule of the product.

W_r^+ = weight of C_r^+ fraction

α = chain growth probability

The extent of deviation from the "constant α" rule appears to depend on the type of catalyst employed. Recently successful operation has been attained at considerably higher selectivities and so the generally held opinion that selectivity and operability are incompatible seems now open to question (*17*).

The effect of pressure on reduction of catalysts was also investigated (*9*). Medium pressure was preferred in reduction with H_2 for two reasons.

First the time for complete reduction at 10 atm. was shortened to 1/10 of its value at atm. abs. pressure. Moreover, the purity of H_2 was less significant when reduction was carried out at medium pressures. Presence of CO and CO_2 up to 3% did not prove to be harmful to the synthesis and moisture content corresponding to the saturation value at 30° C. was found tolerable. This is in striking contrast with previous work (*17*).

Catalysts were tested for their resistance to oxidation by a CO_2 treatment: carbon dioxide was passed over the catalyst under synthesis conditions for 12 hr. and then the synthesis was resumed to see if any decline in activity occurred. This presented a quick check in addition to the routine test of durability.

Table 1.—Comparison of Different Methods of Analyses for Exit Gases

Sample	method of analysis	Composition, vol. % H_2	N_2	CH_4	C_2H_6	C_3H_8	C_4H_{10}	C_2H_4	C_3H_6	C_4H_8
01	CA	21.7	20.2	18.6	20.1	9.7	9.3	...	...	...
01	L	21.4	20.3	18.5	20.3	9.3	9.6	...	...	...
02	L		82.2		6.8	3.0	1.9	1.2	3.6	1.3
02	CS		81.6		6.6	3.1	2.1	1.2	3.5	1.7

CA = gas-solid chromatography, using active carbon as adsorbent
CS = gas-solid chromatography, using silica gel as adsorbent
L = low-temperature fractionation, using a microcolumn

Analysis and Stoichiometry

The investigation of product distribution and catalyst selectivity called for a new scheme of analysis (*8*). A gas-solid chromatographic method similar to that proposed by Janak (*9*), with CO_2 as eluent and active carbon absorbent, was used together with the conventional Orsat method for the analysis of feed and exit gases. The composition of twelve components, i.e., CO_2, C_2^+ olefins, C_2H_4, O_2, CO, H_2, N_2, CH_4, C_2H_6, C_3H_8, C_4H_{10}, and C_5^+ paraffins was obtained in about an hour, with an average deviation between parallel runs of less than 0.2%. (The deviation could be reduced further to less than 0.05% with a modified procedure.) Results also agreed well with those obtained by low-temperature fractionations with a microcolumn. Substitution of thermally treated silica gel for active carbon as the adsorbent in the chromatographic column gave the analyses of a mixture of CH_4, C_2H_6, C_2H_4, C_3H_6, C_3H_8, and C_4H_{10} immediately. Typical results are shown in Table 1. By this simple and expedient method methane, ethane, and

Fig. 1. Flow diagram of pilot plant.

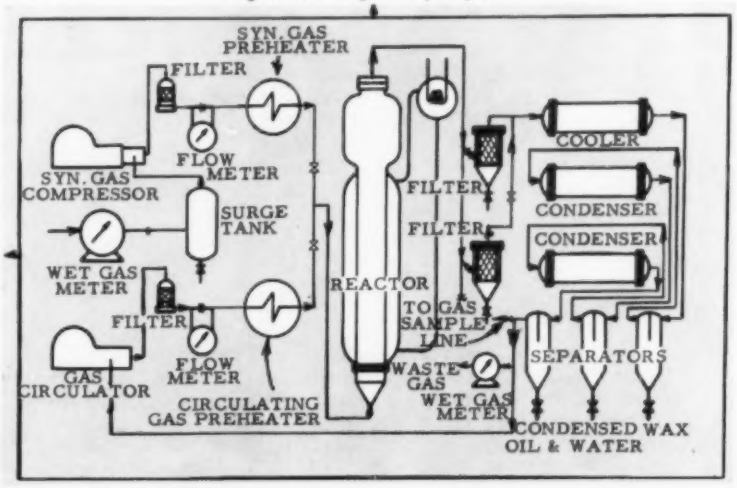

Table 2.—Operating Conditions, Conversions and Yields Obtained in Pilot Plant and Small Fluid Unit Runs

Reactor	30-liter unit								2-liter unit
Experiment No.	500				700				037
Type of catalyst	nitrided				nitrided				nitrided and alkalized
Hours on stream	120	530	780	1,120	90	420	910	1,500	600–928
Temperature, ° C.	260	260	260	260	260	275	260	260	260
Pressure, atm.	15	15	15	15	15	15	15	15	25
Space velocity *	850	1,060	1,200	1,000	800	800	800	1,800	863
Recycle ratio	4	4	4	4	4	6	6	2.5	4
Contraction, %	62.1	58.7	57.3	57.7	56.9	59.7	62.2	60.5	64.8
CO conversion, %	92.2	92.2	90.1	89.2	87.7	88.1	90.7	92.4	94.0
H_2/CO feed ratio	1.36	1.21	1.24	1.28	1.28	1.30	1.26	1.27	1.34
H_2/CO usage ratio	1.23	1.08	1.13	1.16	1.15	1.21	1.24	1.16	1.21
Product distribution, wt. %									
C_1	11.6	17.4	17.7	17.4	15.5	16.2	16.9	.....	7.8
$C_2+C_2^=$	12.1	13.0	13.6	13.4	9.7	10.7	12.0	.....	8.8
C_3	7.0	7.7	7.5	6.0	17.2	17.9	20.5	.....	11.5
$C_3^=$	7.8	7.2	7.5	9.0					
C_4	7.2	6.7	8.4	7.5	9.9	11.0	11.2	.....	8.4
$C_4^=$	4.9	4.4	3.0	3.5					
C_5-C_{11}	35.1	31.0	32.3	33.5	34.9	31.4	29.5	.....	35.2
C_{12}^+	5.6	3.7	3.1	3.4	7.7	5.8	4.8	.....	11.3
Oxygenates	8.7	8.9	6.9	6.3	7.4	6.4	4.3	.....	15.9
Loss	.....	.....	.....	.....	0.7	0.6	0.8	.....	1.1

* Liters synthesis gas S.T.P./liter of catalyst per hour.

ethylene could be determined and C_3^+ yields calculated therefrom (*10, 11*).

The oxygenated compounds in both the aqueous and oil layers of the products were determined for their functional groups by chemical analysis. The aqueous phase was also analyzed for its total organic carbon. Such a scheme has proved to be more straightforward than that of Bashkirov (*12*) in stoichiometric computations.

In the calculation of theoretical yields hydrogen, oxygen, and "contraction" balances were made along with the usual carbon balance. Volume contractors computed by formulas similar to those derived by Rapoport (*13*) were employed in preference to measured contractions, as the latter values were subject to greater experimental errors. A number of interesting stoichiometric relationships have been derived (*14*). Two of them are:

$$c = \tfrac{1}{3}\left(2 - u + m - e + \Delta\right)$$

$$c = \tfrac{1}{4}\left(3 + \Delta - \frac{K}{N_{CO}x}\right)$$

where c.m.e. = moles of CO_2, CH_4, and C_2H_6 formed respectively,/mole of CO reacted.

u = H_2/CO consumption ratio
K = volume contraction, %
x = CO conversion, %
N_{CO} = mole fraction of CO in feed gas.
Δ = a minor correction term, which involves the degree of unsaturation of C_3^+ hydrocarbons and carbonyl and carboxyl formation and which can usually be neglected.

In the laboratory, referred to in this article, the calculated C_3^+ yield and the actual yield generally agree to within ±5%.

Pilot Plant Synthesis Studies

Erected in 1953, the pilot plant had a daily fresh gas throughput of 500 cu. m. (see Figures 1 and 2). A "wet" recycle flow system was employed in the plant, the recycle stream being saturated at room temperature with C_3^+ hydrocarbons. The reactor was a 150 mm. × 4 m. seamless steel pipe, which was topped with a disengaging section of 300 m. × 2 m. and was surrounded by a cooling jacket. Heat of reaction was removed by circulation of a naphthalene-diphenyl oxide mixture in the jacket. Along th ereactor there was a total of twenty-six equally spaced side taps, which serve as thermocouple wells and presure taps as well as sampling stations for catalyst and reacting gas.

Eight runs have already been performed in the pilot plant. Table 2 summarizes the pertinent data obtained from two runs of 1,000-1,500-hr. duration as well as one run performed in the small fluid unit on an alkalized catalyst. It can be seen that the durability of the catalysts was satisfactory and variations in the space velocity did not lead to marked changes in conversion. Both runs were terminated without any loss in operability. The shift of product distribution toward lighter fractions was noticeable. However, this change was considerable only in the initial period of synthesis. Similarly, the yield of methane increased rapidly during the first 500 hr., and remained constant thereafter. The increase in yield of ethane with time was only slight. The yield of oxygenates tended to decrease during synthesis.

Composition changes of the catalyst were analyzed by taking samples from the reactor at regular intervals. The results were comparable with those reported by Anderson (*2*). The displacement of nitrogen by carbon in the catalyst was clearly observed. This displacement action proceeded rapidly in the first 200 hr. and leveled off afterwards. The $(C+N)/Fe$ atom ratio remained constant during the course of synthesis. The O/Fe atom ratio, however, showed a gradual increase.

Hall and Taylor (*15*) considered the back mixing of gases in fluidized beds undesirable and stressed the importance of the height-diameter ratio in scaling up the reactors. It is felt that this point is somewhat overemphasized for processes using recycle operations, as recycle would bring the gas composition between bed inlet and exit close to each other, thus minimizing the effect of any back mixing. On the assumption that the synthesis reaction is of the first order, the decrease of conversion due to complete mixing was calculated to be 3.5% for a recycle ratio of 4. In the experiment described, gas samples were taken from various parts of the 6-in. reactor and the 1¼-in. unit. Analyses showed that flow pattern in the 6-in. reactor approached that of complete mixing, while in the 1¼-in. unit gas flow was essentially rodlike. CO conversions in parallel runs performed in the two reactors differed by 3.4-4.6% which checked well with the predicted value. The product distributions in parallel runs were also compared. Reproducibility was good, and if differences ap-

peared, the larger unit gave better results. In the light of the above facts, it is unlikely that further scale-up of the reactor should bring any decrease in activity or selectivity.

Characteristics of Products

The character of the gasoline fraction of a typical primary product is indicated in Table 3. Its direct use as motor fuel should be adequate. Storage tests were made and the increase in gum content is shown in Table 4. In sample 1 no gum inhibitor was added, while sample 2 contained 0.005% of N-N'-*p*-di-sec-butyl phenylene diamine. Data showed that improvement in stability was obtained through the addition of the inhibitor.

The synthesis product differed appreciably from that reported in the literature (*2*) in that lower yields of oxygenated compounds were obtained. Over the wide range of process variables studied, the aqueous organic carbon never exceeded 10% of C_3^+ yield and the oxygen content in the oil layer was about 1%. Alkali addition to the catalyst, however, doubled the oxygenates yield.

Component analyses of oxygenated compounds in aqueous and oil layers are given in Table 5. The analyses of oxygenates in the oil phase is now in progress.

Study of Cobalt Catalyst

Besides, an investigation was made of the conventional Fischer-Tropsch synthesis, particularly the catalysts. Zhen (*19*) found that during the preparation of the catalyst, a part of the $CoCO_3$ reacts with the surface layer of kieselguhr—forming surface complex, which exerts a rather prominent influence on the activity, namely an amount of 5-30% metallic Co in the form of surface complex is necessary for the improvement of the activity of the catalyst.

These catalysts, reduced and unreduced, were studied for their surface texture (*20*). The surface area B.E.T. (Brunance, Emmett Teller)* and number of pores of radius about 20 Å increase with the complex content. When the percentage of Co (complex) is larger than 30%, the isotherms of catalysts exhibt knifelike desorption curves at $P/P_o = 0.05$, corresponding to lower activity. When it is smaller than 30%, its isotherms exhibit narrow hysteresis loops, corresponding to normal activity.

With regard to the influence of preparation temperature, it was found that two catalysts, although having the same content of surface complex, show different activities when prepared at different temperatures; those which were prepared at lower temperature exhibit better activity and contain fewer pores of 20 Å radius (*21*).

* Equation for isotherm.

Table 3.—Properties of Primary Gasoline (C_3^+ — 200°)

Item			
1. Engler distillation			° C.
	1st drop		39
	10%		53
	50%		78
	90%		152
	End point		177
2. Vapor pressure		mm. Hg.	424
3. Octane rating		clear	62
		plus T.E.L. 1.3 g./kg. oil	77
4. Bromine No.		g./100 g. oil	111
5. Acid No.		g. KOH/100 g. oil	2.8
6. Gum		mg./100 ml. oil	2
7. Corrosion test			pass

Table 4.—Gum Content of Primary Gasoline During Storage Test

Duration of test	Gum mg./100 ml. oil Sample 1	Sample 2
0	< 2	< 2
3 months	< 2	2 .6
10 months	3.6	5.0
12 months	13.8	4.4

Table 5.—Component Analyses of Oxygenated Compounds in the Condensed Aqueous Layer

Composition	Wt. % condensed water		Wt.% total oxygenates in condensed water	
Type of Catalyst	Nitrided	Nitrided and alkalized	Nitrided	Nitrided and alkalized
Component				
Methanol	0.93	0.19	10.5	1.1
Ethanol	4.39	7.26	49.5	40.0
Propanols	1.87	1.48	21.1	8.2
Butanols & higher alcohols	0.65	0.41	7.3	2.3
Acetone	0.31	0.28	3.5	1.6
Butanone	0.19	0.14	2.1	0.8
Pentanones	0.17	0.04	1.9	0.2
Hexanones & higher ketones	0.01	0.02	0.1	0.1
Acetic acid	0.29	5.17	3.3	28.6
Propinic acid	0.09	1.14	1.0	6.3
Butyric & higher acids	0.06	1.96	0.7	10.8
Total	8.87	18.09	100.0	100.0

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Cost Trends and Controls in PHARMACEUTICALS

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Here is offered a rudimentary method for estimating the effect of continued production on manufacturing cost. Its application in a particular case will depend, in large measure, on the considered judgment of the user.

We have passed through the era of the palliative and nutritional deficiency remedies. We are now in the age of anti-infection therapy and prophylaxis and, are entering the field of mental health therapy. Ahead, lies the battle against degenerative disease. It does not seem likely that remedial measures in support of vital body functions, weakened or damaged by disease or old age, can be achieved with a few doses of some magic elixir. Instead we may expect therapy based on regular dosage over long periods of time. The increase in life expectancy is almost certain to be accompanied by an increase in medical expenses.

It is understandable that there should be interest in the costs of pharmaceuticals. Each of us may someday require a particular drug for its therapeutic effect in an emergency. While no price may seem too great to pay for an effective remedy in the stress of the moment, we are still interested in minimizing the impact of such an emergency on our budget as well as on our health.

In the case of an ethical drug (one prescribed by a doctor and dispensed by a pharmacist) we are seldom in a position to choose between manufacturers. However, the high standards of American pharmaceutical manufacturers, the constant intense competition (both direct and indirect) between manufacturers at the physicians level, and the protective role of the physician towards his patient substitute for the usual competition at consumer level.

Cost Trends

The cost of the average prescription for the consumer has risen about 5% per year since 1948. Since the average number of prescriptions per family has increased by about ⅓ in that time, the average amount spent per family on prescriptions has increased at a rate of about 9% per year. See Figure 1.

The average family is supplied with more drugs of greater effectiveness each year and yet the proportion of personal consumption expenditures allotted to drugs and sundries continues to decrease. See Figure 2. This trend may reverse itself in spite of increasing personal income. Ewell (*1*) has pointed out that as more and better drugs become available, expenditures for them are likely to take precedence over other personal consumption expenditures.

The trend towards higher consumer prices for ethical drugs, reflects higher manufacturing costs. On closer examination of the price history of indi-

FIG. 1
ANNUAL PRESCRIPTION SPENDING PER FAMILY

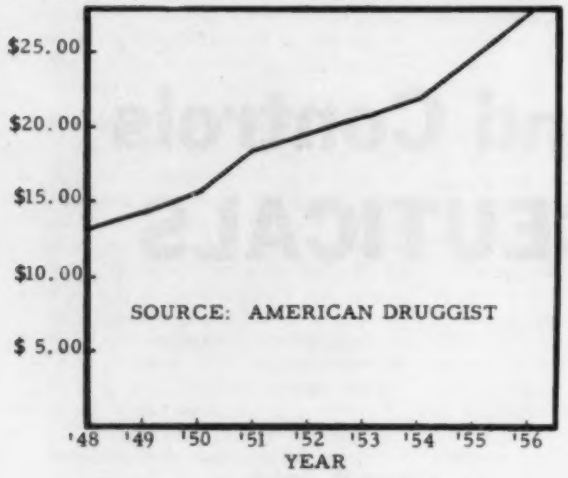


FIG. 2
SPENDING FOR DRUGS & SUNDRIES AS PER CENT OF TOTAL PERSONAL EXPENDITURES

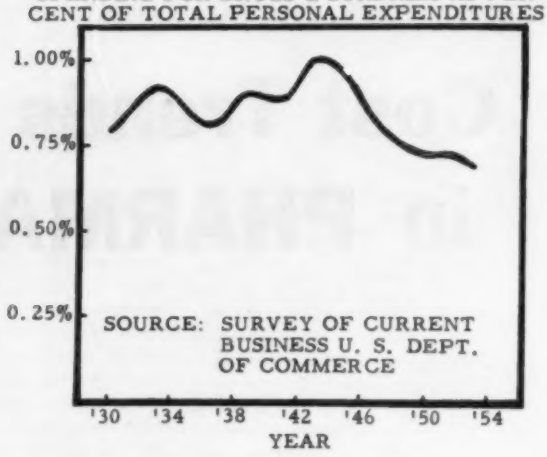


FIG. 3
ASPIRIN PRODUCTION

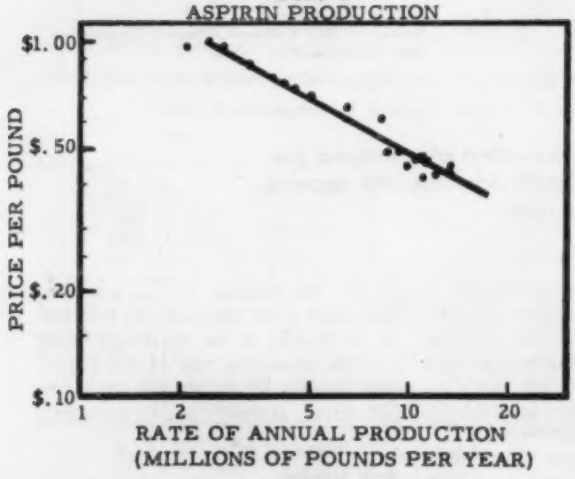


FIG. 4
PRODUCTION OF PENICILLIN

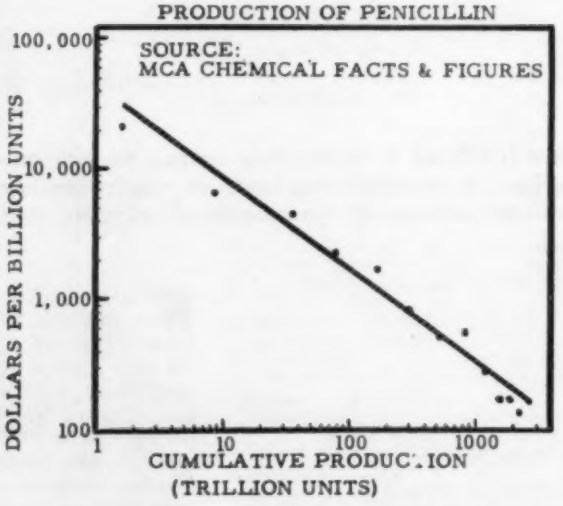


FIG. 5
PRODUCTION OF STREPTOMYCIN AND DIHYDROSTREPTOMYCIN

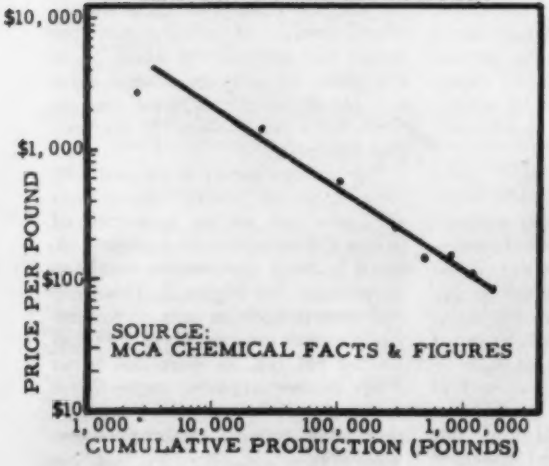
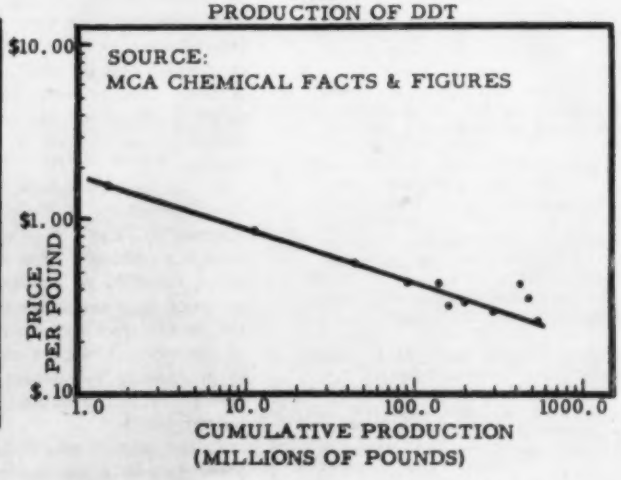


FIG. 6
PRODUCTION OF DDT



vidual bulk chemicals one finds that with few exceptions, the price decreases or holds constant year after year. In spite of increased cost of materials, labor, and overhead items, manufacturing economies are achieved by improved processes, larger batches, and more efficient equipment.

The rise in the average prescription price is due to the continuing introduction of new and more complex medicinals. Improved techniques and better equipment have permitted the isolation of sensitive natural products which could not have been considered twenty years ago. Tranquilizing agents and the steroidal hormones, used in the treatment of arthritis and various metabolic disturbances, are the products of difficult, multistep syntheses. It is this change in "product mix" that has led to the increasing cost of the ingredients of the average prescription.

Cost Control

A discussion of cost trends leads naturally to consideration of cost control. In turn, cost control usually implies a comparison to some standard. The general techniques of detailed cost analysis are well known and need not be described here. Instead, we are seeking a means of forming an approximate judgment of the cost trend for a particular product to provide the management of an enterprise with an additional line of reference which might (even if only approximate) serve as a cross check on existing data.

First, consider that group of medicinals which have been in production for so long and in such volume that they may be considered industrial chemicals. Schuman (*2*) has shown that for industrial chemicals in general, if unit price is plotted versus production rate on log-log paper, the data give a straight line with negative slope −0.346. Aspirin is a typical member of this class with a slope of about −0.500. See Figure 3, which represents data from U. S. Tariff Commission Reports over a twenty-year period.* Accumulation of similar data on other products is needed to draw any general conclusions. Unfortunately the high rate of product obsolescence in the drug industry precludes the use of this type of correlation on most products.

Price Predictions

It is of some interest to seek a method of price prediction applicable to those pharmaceuticals which appear spectacularly from the research laboratory and clinical evaluation to fill long-felt needs. Perhaps one of the earlier ones that comes to mind is penicillin. Dr. Henry Welch, Director of the Antibiotic Division of the Food and Drug Administration, has commented that in 1943, 100,000 units of penicillin cost $20 at the manufacturers' level. In 1953 the value of the same amount of material to the manufacturer was only about two cents. This is a thousand-fold decrease in cost in 10 years and yet the material produced in 1953 was of much higher quality.

The characteristics of the so-called new "wonder-drug" may be summed up as follows:

1. There is great pressure to produce the initial requirements with relatively little regard for cost of material, manpower or equipment.
2. The initial production can be sold for a high price.
3. The demand and price structure quickly brings direct or indirect competition.
4. After the initial production there is great pressure to improve manufacturing processes and introduce process and engineering economies.
5. Eventually, if the product remains on the market long enough, it becomes subject to the economic relations which apply to industrial chemicals.

Because first deliveries must be made before final process equipment is completed, the first new products must be practically handmade. The next group will probably be fabricated by the pilot plant; the next group by other intermediate equipment; and finally, after many modifications have been produced with substitute equipment, subsequent products will be fabricated in quantity production equipment.

These words should sound familiar to those who have worked on the engineering development and production of new drugs. It is a truism that the wonder drug of today is produced in the equipment purchased for the efficient production of the wonder drug of yesterday; and the money appropriated for process improvement is all too often spent in putting into production the wonder drug of tomorrow!

In the aircraft industry about twenty years ago, T. P. Wright introduced the concept of the Learning Curve (*3*) to show the effect of continuing production on reducing unit costs. In that industry it is generally accepted that the cumulative average unit cost is decreased to 80% of its initial value when the cumulative production is doubled. This is expressed as a simple exponential equation in which cumulative average price is equal to a constant times the cumulative production to a negative fractional power. It can be shown that after its initial jog, the unit average curve parallels the cumulative average curve. We shall attempt to extend the learning curve to the pharmaceutical industry.

In the highly competitive drug industry there are relatively little published data available to test this thesis except for Chemical Data Handbook figures on penicillin and streptomycin which were assembled from U. S. Tariff Commission Reports. Figure 4 shows cumulative production of penicillin plotted on log-log scale versus the weighted unit selling price. Data for streptomycin products are shown in the same fashion in Figure 5. In each case the data approximate a straight line. The exponent derived from the slope of the line is −0.71 for penicillin and −0.625 for streptomycin. Doubling the cumulative production leads in one case to a price 61% of the original price and in the other 65% of the original price. These would be called 61% and 65% learning curves.

There is one other set of chemical price data available which was generated under approximately the same conditions as those for penicillin and streptomycin. While not strictly a pharmaceutical, the insecticide DDT was first produced as a health measure under the stress of wartime demand. The data are shown in Figure 6. Once more the plot approximates a straight line, this time with an exponent −0.305, which is about an 81% learning curve.

In the manufacture of chemicals the "learning" process may result in better yields and greater productivity of men and equipment. In many cases in which the technology is not wholly new the possible gain is limited. Perhaps this explains why the learning curve for DDT approximates that for the aircraft industry. On the other hand, the amount of penicillin in a volume of fermentation broth today may be a hundred times what it was in its early development. This may, in large part account for the greater "learning" rate for these antibiotics.

* Since these data extend over a rather long time interval, prices are corrected using the chemicals price index with 1947-1949 average as a base.

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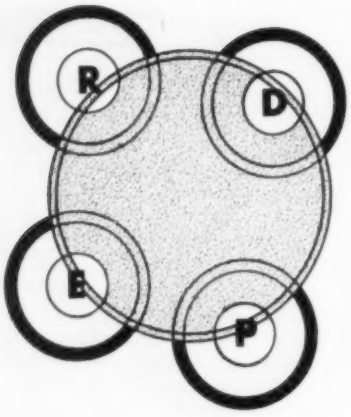

PROCESS EVALUATION

Close and continuing liaison is necessary between Research, Development, Production, and Engineering groups for the satisfactory design of a facility to manufacture a new product.

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Research is essential for the promotion of healthy growth in the chemical industry. The problems which must be solved if the products of research are to be successfully realized, are the subject of this article. These are principally the problems which arise in the relationship between Research, Production, and Engineering groups of an organization, say, like DuPont.

Over the past twenty years every dollar Du Pont has spent on research has resulted in the expenditure of nearly three dollars for the expansion and construction of plants. Currently about half of Du Pont's sales result from products that were unknown or in their commercial infancy twenty years ago. Production and sale of these new products are now giving employment to more than 34,000 workers.

Research, however, is not an end in itself, nor is the development of a new or useful product a satisfactory conclusion to a research effort. Successful research must result in profits from the commercial production of a new or improved material. This is the real measure of success.

The road from research to reality is a bumpy one, ill-marked and with many detours and blind alleys. On this road many wonderful scientific achievements of research suffer economic catastrophies. Successful production and sale of a new product require extensive cooperation between Research, Engineering, Production, and Sales. This cooperation should start in the research laboratory—or better yet, in the library where the research scientist makes his initial literature survey.

Imagine the absurdity of designing a complete chemical plant—reactors, heat exchangers, columns, filters—specifying steam and water facilities, laying out buildings and warehouses, and then turning the job over to a research group to develop a product and process to fit this plant. On the other hand, imagine developing a product and a complete process for its production and giving no regard to the nature of the commercial facility—no worries about reactors, heat exchangers, columns, filters, steam and water facilities, building layouts, and warehouses. As the research man might put it, these are minor details to be worked out by the Engineering Department. It should be obvious that each of these approaches is equally absurd. Fortunately industry has learned not to proceed via these methods and consequently has been successful in reaping some of the potential benefits from collaboration between the Research, Production, and Engineering groups.

Some advantages of conducting development work with a watchful eye on the nature of the final commercial facilities are listed below.

1. Since major profits can result from the early marketing of a new product, this cooperation can permit the research group to produce the data necessary for engineering design early enough so as not to delay construction.
2. Since direct scale-up of test tubes, beakers, and stirring rods does not usually result in the most efficient plant, cooperation in the early stages will allow the design of more economical production facilities.

3. Early participation of production and engineering personnel in the research program can aid in avoiding operating problems by considering them in research and plant design.
4. Although heat, steam, and refrigeration are minor costs in the laboratory and may be used freely or even excessively, this is not the case in commercial facilities. This type of cooperation can assure that attention will be paid to the minimum use of utilities in all stages of the process design.

As an example of the value of close cooperation concerning seemingly unimportant details, consider the following:

To bring a new product to full-scale commercial production, many decisions must be made during the development of the process—decisions which are often made without a clear understanding of their commercial implications. To pack a beaker with ice in the laboratory might cost 25¢. To carry out the same reaction at the same temperature on a commercial scale might involve refrigeration expenses amounting to hundreds of thousands of dollars.

The following is an example of the type of engineering evaluation which can be of use in the direction or redirection of the research effort. An original process specification required a distillation to be carried out at 25 mm. Hg abs. pressure. Since this required the provision of a refrigerated condenser, the need for this degree of vacuum was questioned. It was pointed out that distillation at a higher pressure, permitting the use of normal river water cooling would cause a serious loss in yield. Table 1 shows the type of evaluation often carried out on a problem of this sort. Three cases were considered; one at higher pressure (100 mm. Hg) and two at low pressure (25 mm. Hg), differing only in the assumed decomposition of the feed. After considering the technical details, tons of refrigeration, pounds of steam per hour, gallons per minute of water and kilowatt hours of electricity, it was possible to make the evaluation shown. Figures for direct plant investment and allocations for various utilities were totalled to give the investment for each case. For operating costs, only the increased material cost, utilities, and maintenance and depreciation were considered, assuming all other costs to be equal. It was determined that even with half as much decomposition there was little choice between the high and low pressure operation. When it was later discovered that there was no appreciable change in decomposition between the lower and higher pressure operation, it became obvious that the higher pressure operation was preferable, giving both a lower investment and a lower yearly cost. This evaluation allowed a reduction of over $300,000 in investment and $75,000 per year in operating cost over the uncritical choice of 25 mm. for the vacuum distillation.

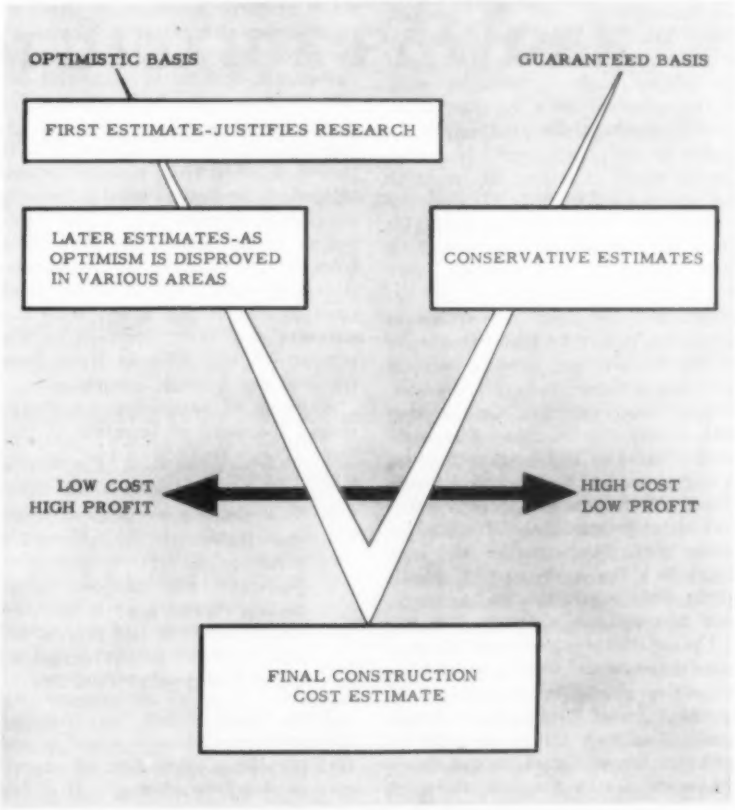
Table 1.—Choice of Operating Pressure for Distillation Column

Operating Pressure, mm. Hg.	25	25	100
Condenser Water Temp., °C.	5	5	30
Assumed Decomposition, % of feed	7.5	15	15
Refrigeration, Tons	580	710	Base
Steam, lb./hr. × 10^{-3}	23	32	31
Water, gal./min. (incl. refrig.)	2,600	3,200	1,800
Electricity, kw. (for refrig.)	540	660	.....
Direct Plant, $	635,000	810,000	590,000
Allocations (steam, water, electric, working capital)	415,000	540,000	430,000
INVESTMENT, $	1,050,000	1,350,000	1,020,000
Increased Material Cost	.....	20,000	20,000
Utilities	114,000	150,000	104,000
Maintenance & Depreciation	106,000	130,000	100,000
Relative Operating Cost, $/Yr.	220,000	300,000	224,000

It is generally believed that it is not feasible to educate the research man to be aware of these considerations. A good research man has enough to learn to carry out his research business. It is deemed more practical to inject engineering economics into the picture by permitting the close association of research scientists and process engineers during all stages of the development.

Problems arise continually during the progress of a project from preliminary research to commercial reality. Decisions must be made continually during this time which reflect upon the nature of the research effort and on the design of the final plant. Therefore, continuous economic evalu-

Fig. 1. Method of converging estimates.



ation of a proposed process from the original concept through final design and construction of commercial facilities, offers major benefits to a company. The benefits to be realized from this continuous evaluation are:

1. Early realization of profits.
2. Maximum return on invested funds.
3. Timely discontinuance of unprofitable projects.
4. Maximum research effort on the major process problems.

Like it or not, every decision made during the development of a project is made after some sort of economic evaluation! This evaluation may be a full-scale estimate of investment or operating costs (rarely feasible) or it may be an off-hand guess that a given process looks desirable (rarely useful). The nature of the evaluation depends upon the information in hand.

There is some merit in making two estimates of the cost of finished product and plant facilities shortly after the conception of a process. This is a new technique in process evaluation. (See Figure 1) One estimate is made on an *optimistic* basis assuming that everything is going to go right; that the problem facing research at this stage will be solved at low cost. The other estimate is made on a *guaranteed* basis. What facilities must be put in to guarantee the manufacture of the product. This brackets the cost, usually a *wide* bracket at this point. If the project looks unprofitable even on the optimistic basis, consider abandoning research. The nature of the profits on the guaranteed basis often has an effect in setting the research and development schedule. If the process appears to be highly profitable (even on the conservative basis), it often means an A-1 priority. Full steam ahead on the research and development! As new information is developed, it may be found that some of the features put into the process on the guaranteed basis are unnecessary, and costs diminish. On the other side, it may also be shown that much of the optimism of the research group is unjustified and the estimate becomes larger. With more and more research and development, the difference between these two estimates can converge to a negligible amount, usually at the point where the final construction cost estimate is made.

During this research and development stage of the process, careful examination should be given to all alternative routes which may be discovered. Maximum return on plant investment depends upon the careful examination of the economic effects of all choices. The goal for the maximum benefits from continuous evaluation is to enter the design stage with enough evaluations completed to choose the most economic route, and enough basic data available to start plant design immediately. To carry out this important function—the continuous economic evaluation of projects from the research stage forward—the problem may be attacked from many viewpoints. We have tried, for example, to develop a general standard method for process evaluation suitable for use by research scientists or development engineers.

However, it has been found that rather than develop a single all-purpose method, it is more practical to develop a group of engineers specializing in this type of work. The type of engineer needed to carry out this important job is a man who can take an unbiased over-all view of the potential process and its economic implications. This generally requires:

1. Broad industrial experience.
2. Technical and economic know-how.
3. Uninhibited and unbiased attitude.

Generally, these requirements can be filled better from outside the research or development organization.

The qualities which make a top-notch research scientist or development engineer are not those best suited for process evaluations. For example: *enthusiasm*, so vital to successful development or research, is almost fatal to the requisite calm evaluation. A man representing an organization completely detached from research or development, is better able to take a completely objective view. The bandwagon is not always the best place from which to make an evaluation. A design engineer should not be called upon to do this job either, since the attitudes and skills involved in his regular job are different from those required for process evaluation.

A group of basic data consultants should specialize in activities of this sort. Their function would be described generally:

1. To evaluate economically and advise technically on alternative processes.
2. To insure that adequate information (basic data) is obtained during research and process development to permit design of economical process facilities.

They would ensure an objective viewpoint on process evaluations and facilitate the accumulation of experience in this type of work. It is felt that at least ten to fifteen years of varied industrial experience is a prerequisite for effective performance in this group. Some junior engineers could add to the general effectivenss by taking over the less difficult, or more repetitive, parts of the evaluation allowing the basic data consultants to concentrate upon the fundamental aspects of the problems. The prerequisite for the basic data consultant is a highly competent engineer with strong leaning towards economics. He must be able to estimate the technical and economic consequences of any process decision, sometimes on very limited data. In short, the basic data consultant must possess "technical tools" such as:

1. Good engineering judgment.
2. Broad and diversified experience.
3. Skill at estimating costs from incomplete data.

The actual estimation of the cost of large blocks of a plant is relatively easy. The literature is replete with methods for quick estimates. Most of them boil down to estimating the installed cost of major equipment (either from published data, company records, or from vendors' quotations), and then adding percentages for piping, instruments, building contingencies, engineering design, etc. Use of these percentage factors requires judgment and/or experience. Usually the completed building and equipment, excluding services, will cost three to four times the cost of "installed equipment" exclusive of piping and instruments. Service facilities should never be estimated as a percentage of process equipment cost. Equipment cannot be properly sized and estimated in the first place without a material and heat balance. This balance makes it easy enough to calculate the requirements for steam, water, electricity, and refrigeration. Cost of service facilities are readily available.

The estimation of alternatives within a process is often necessary. Sometimes this estimate is relatively simple. Sometimes it is more complex and more difficult than a complete plant. Where very few equipment pieces are involved, the use of percentage factors is dangerous. For instance, it does not cost twice as much to instrument a 50-plate column as it does a 20-plate column, although the column itself may cost even more than twice as much. Water piping to a stainless steel condenser costs no more than to a less expensive carbon steel unit for the same service. Alternatives should always be compared on a differential basis; that is, leave out of the estimate everything that is duplicated in the alternative processes.

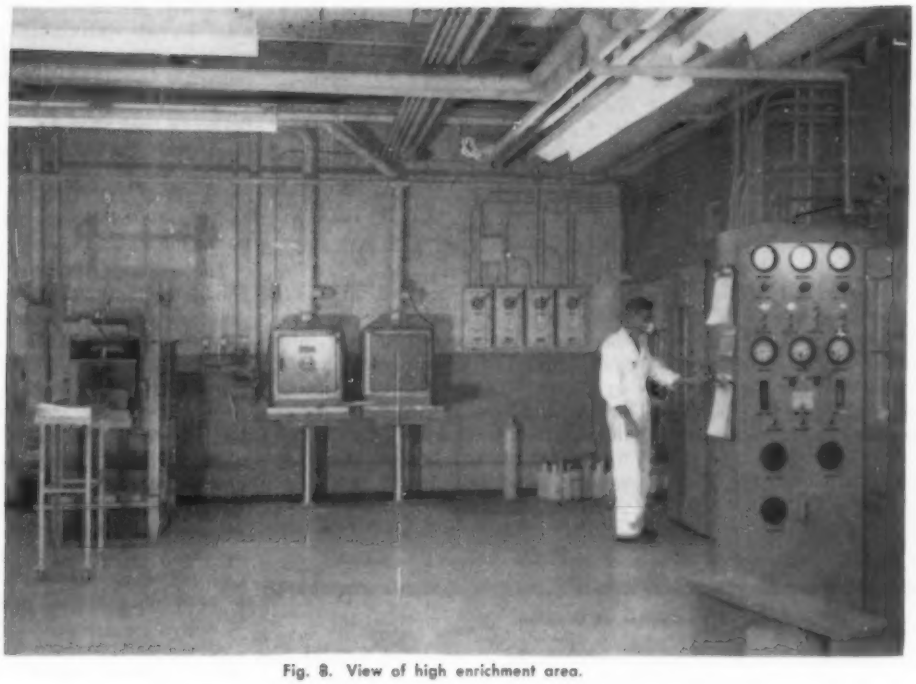


Fig. 8. View of high enrichment area.

preparation and properties of URANIUM DIOXIDE POWDER

Commercial preparation of UO_2 is described with emphasis on the two methods which have had wide application in the actual production of the dioxide for fuel element raw material. Physical properties of UO_2 powder are related to their importance in fuel element use.

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Highly purified uranium dioxide is in many respects an ideal material for the fabrication of fuel elements for atomic reactors. While its density is not equal to that of the metal or many possible alloys, it compares very favorably with most other stable compounds of the element which might be chosen. It is thermally stable up to its very high melting point (about 5,000° F.). The UO_2 lattice will accommodate foreign atoms to a marked degree without a change in crystal structure. This permits the accommodation of fission products without large dimensional changes. It is relatively stable to the action of high temperature water, as compared to uranium metal or alloys. Since UO_2 is isotropic, it is not subject to oriented dimensional changes when subjected to thermal cycling or irradiation. Its oxygen content is of low neutron cross section. These properties are sufficient to make it the material of choice for power reactors, where both high temperature and high burn-up are involved.

As a powder, the properties of UO_2 are dependent on its method of preparation. Chemical reactivity, bulk density, surface area, crystallite size, porosity, and even oxygen/uranium ratio are grossly affected by the history of the powder. The phase relationships of uranium oxides of compositions between UO_2 and UO_3 are quite complex as indicated in Table 1.

The absolute density of UO_2, while high for a nonmetal, is still low enough to make it imperative to approach its full utilization in fuel elements compacted from powders. The suitability of a UO_2 powder for fuel element fabrication, therefore, is judged partly by its behavior on compaction and sintering. It was early evident that the well-known tendency of UO_2 to oxidize at low temperatures was related to its sinterability. Early practice of high-temperature re-

duction to promote stability toward oxidation led to difficult sintering. The O/U ratio was close to theoretical, in general being less than 2.05. Methods of preparation giving products of high O/U ratio resulted in a material which sintered more readily.

Other work indicates that the physical condition of UO_2 particles is of great importance in determining the sinterability of a UO_2 powder. According to Westinghouse (*7*), powders with large surface area, high density, large "roughness factor," and narrow pore size distribution have excellent sintering characteristics. Comminution of poorly sintering powders greatly improves their sintering characteristics. Work at Battelle on ball-milling and at Mallinckrodt on Micronizing is consistent with these conclusions.

lons while the largest sizes are about 250 U.S. gallons. This is mentioned because the resulting products appear to differ in reactivity. The denitration cycle is longer, and hence the denitration slower, in the larger pots. The product from the smaller pots has a larger proportion of the Type III UO_3. Such differences in type of trioxide and in reactivity affect the reduction to dioxide and the final properties of the dioxide powder. The exact relationship between these effects and the quality of the dioxide for ceramic purposes is not yet fully understood, but is recognized to be an important factor worthy of continued investigation. Figure 1 shows the two most common denitration kettles in use. It will be seen that they are the same in principle and differ only in size.

In the operation of denitration pots

Table 1.—Oxides of Uranium

Formula	Cell Type	Lattice, Å	Literature Cited
$UO_{2.00}$	FCC	5.4704	(*1*)
		5.4682	(*2*)
$UO_{2.50}$ (metastable)	FCC	5.4462	(*1*)
$UO_{2.25}(U_4O_9)$	FCC	5.4411	(*1*)
$UO_{2.33}(U_3O_7)$	Tetragonal	$a = 5.45$, $c = 5.40$	(*3*)
$UO_{2.60}$	Orthorhombic	$a = 6.734$, $b = 3.966$, $c = 4.144$	(*1*)
$UO_{2.67}$	Orthorhombic	$a = 6.7198$, $b = 3.983$, $c = 4.1462$	(*1*)
$UO_{2.88}$	Cubic	4.138	(*4*)
$UO_{3.0}$	Amorphous (Yellow)		
$UO_{3.0}$(I)	Hexagonal (Red to Black)	$a = 3.963$, $c = 4.160$	(*5*)
$UO_{3.0}$(II)	Poorly crystallized (Red)		(*6*)
$UO_{3.0}$(III)	Orthorhombic (Orange)	$a = 13.01$, $b = 10.72$, $c = 7.51$	(*6*)
$UO_{3.0}$(IV)	Cubic	4.146	(*4*)

UO_2 by Denitration of Uranyl Nitrate and Hydrogen Reduction

By far the largest quantities of uranium dioxide have been prepared by denitration of uranyl nitrate followed by hydrogen reduction and this may well be considered as the historical or classical method of preparation. While most of this oxide has been converted to tetrafluoride and then to either metal or hexafluoride, sizeable quantities have been used directly in fuel element work. Such oxide may be used directly as obtained from the reduction furnaces, or subsequent to certain after-treatments to be discussed later in this paper.

Denitration may be carried out in batch kettles or continuously. Most production work has been done in gas heated, stirred, stainless steel pots differing from one plant to another chiefly in size. The smallest size in use has a capacity of 45-50 U.S. gal-

the container is filled almost to the brim with molten uranyl nitrate hexahydrate (B.P. 248° F.). As heating is continued the stirred mass first becomes cloudy, nitric oxide fumes are evolved, and gradually the mixture of solids and liquid becomes doughlike in character. Finally the dough breaks up into a yellow-orange powder. After a degassing period, the heat is turned off while stirring is continued. The warm powder is unloaded from the pot by a vacuum gulper, to minimize exposure of the operator to UO_3 dust. The time cycle varies with the size of the pot.

The continuous methods for the denitration of UNH generally depend upon the addition of concentrated uranyl nitrate solutions to a hot layer of UO_3 powder, either in a horizontal stirred bed (*8*) or in a fluidized bed (*9*). The UO_3 is drawn off at a point as remote from the addition of

the uranyl nitrate solution as practicable. To date such continuous methods of UO_3 production have not been important in preparing the forerunner for uranium dioxide for use as such, but may well become important as they tend to give a rather different particle shape from that obtained by batch methods. Figure 2 shows the construction of a horizontal stirred bed denitrator (*8*).

The reduction of the trioxide to dioxide at high temperature by hydrogen or by cracked ammonia (75% H_2, 25% N_2) may also be carried out continuously or in batches. This was originally done by loading trioxide powder in stainless steel trays about 1½ in. deep and placing these trays in a stainless steel box in an electric oven at 1,500° F. Hydrogen gas was passed through the boxes for six hours to effect the reduction, and the product was cooled in hydrogen to nearly room temperature to prevent reoxidation upon exposure to air.

Continuous methods have now almost completely replaced the batch methods for this step. The uranium trioxide, produced by the thermal denitration of uranyl nitrate as described above, is fed into one end of a horizontal cylindrical tube 22 ft. long and 16 in. in diameter. This stainless steel reactor tube has within it a rotating agitator-conveyor made in the form of a reel-type lawn mower. The ribbons of the conveyer, however, have their flat sides perpendicular to the diameter of the tube. The conveyor can be turned quite readily without imparting much forward motion to the powder, i.e., the action is essentially that of stirring. Small pusher blades are added to move the powder forward at the chosen rate. A central shaft is used to prevent sagging with consequent "galling" between the agitator and the tube. The conveyor speed is controlled accurately by means of a variable volume hydraulic system. The reactor tube rests in an electric furnace which is divided into four heating zones. The temperature is controlled in each of these zones by means of thermocouples inserted through the furnace shell near the center of each zone. Figure 3 shows the general construction of a continuous reduction reactor.

Cracked ammonia gas is passed through the reactor countercurrent to the powder. About one and one-half times the theoretical amount is required and the excess is burned at the gas discharge end. Dust carried through is collected in a bag-type collector from the cooled combustion gases. The quality of the product may

be controlled somewhat by the temperature in the furnace, which is normally from 1,200° F. to 1,500° F. The material made at the lower temperature is very reactive and partially reoxidizes on exposure to air even when thoroughly cooled. However, this may not be important since, when ceramic elements of dioxide are fired in a reducing atmosphere, reconversion to UO_2 will occur. Nevertheless, material reduced at 1,400° F.-1,500° F. has most generally been used for ceramic work since it is more stable and its properties are better understood.

UO_2 by Ammonium Diuranate Precipitation and H_2 Reduction

Most power reactors are designed for a fuel enriched in U^{235} content. Therefore, any fuel element material for such reactors must be made from a uranium hexafluoride starting material. The production of UO_2 from the hexafluoride is carried out through an ammonium diuranate intermediate, and this UO_2, when made from this intermediate, is frequently referred to as ADU type brown oxide. The use of this ADU intermediate has proven convenient for the hydrolysis of the hexafluoride, and also has led to a uranium dioxide of especially good ceramic properties.

At a plant near St. Louis, Missouri *(10)*, ADU type brown oxide is manufactured commercially in either of two enrichment ranges. With material containing up to 3% U^{235}, protection against criticality accidents is obtained by simply limiting the quantity of material in any one batch. In the enrichment range of 20% and up all equipment is designed to provide always-safe geometry. The shape of all containers is such that under no conditions can a critical situation be obtained irrespective of the enrichment or concentration of the material being worked. Cylindrical vessels for liquors are limited to 5-in. diam. and trays of powders are restricted to a maximum of 1¼ in. thick.

Although the scale of equipment is quite different depending on whether one is processing high or low enrichment material, the basic flow sheet employed for the production of ADU type UO_2 is identical. This flow sheet is shown in Figure 4 together with the reactions involved.

Basically the process consists of the hydrolysis of UF_6, supplied by the AEC, with a dilute ammonia solution to give a precipitate of ammonium diuranate. This ADU is filtered, washed, and dried. The dried powder is pyrohydrolyzed with steam at 1,470-1,560° F., and at the same time the ammonium diuranate is converted to black oxide. This U_3O_8 is finally reduced to brown oxide with hydrogen or cracked ammonia at 1,470° F. If the oxide is to be compressed into solid UO_2 fuel elements, the reduced product is simply ground and packaged. On the other hand, if the end use is as a component in a matrix-type fuel element, the ground product is fired at temperatures up to 3,090° F., cooled, ground, and screened before packaging.

Figure 5 is a picture of the equipment used in the hydrolysis step.

The uranium hexafluoride is vaporized in its cylinder by heating and is passed into a stream of recycling ammonia solution. Aqueous ammonia is continuously fed to the hydrolysis reactor at about the same rate as the hexafluoride. These feed rates are controlled such that the aqueous slurry always contains an excess of ammonia and at the end of the precipitation this excess is increased somewhat. A heat exchanger in the recirculation line removes the heat of reaction maintaining a temperature of 86-104° F. The equipment used for the high enrichment batches is identical in principle with that shown except for

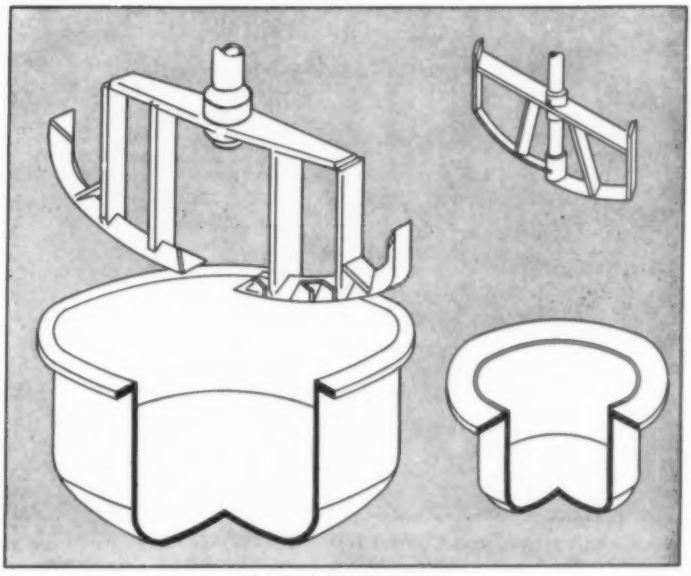
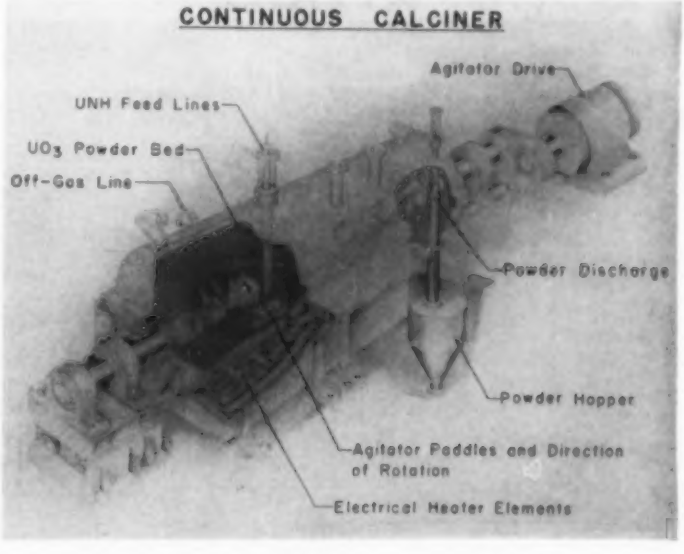


Fig. 1. Denitration pots.

Fig. 2. Horizontal stirred bed denitrator.



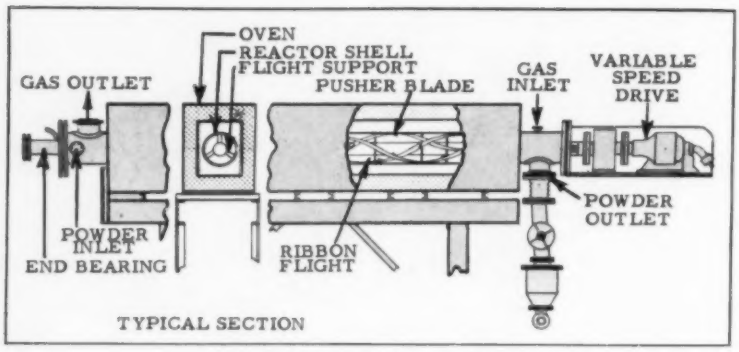


Fig. 3. Continuous reduction reactor.

scale, for example, the vessels are limited to 5 in. in diam.

Filtration of low enrichment batches of ADU is done on a rubber-lined filter press and the high enrichment batches on stainless steel Buchner type funnels. The ease of filtration, as well as the bulk density and ultimate particle size of the final product, is very sensitive to the manner in which this precipitation and the washing of the cake are carried out. By careful control of these factors the bulk densities of the product ceramic UO_2 can be controlled over the range 1.5-5.0 g./cc.

The washed ADU is placed in an electric, circulating-air oven in stainless steel trays at 347° F. This oven is fitted with a liner that prevents stacking of trays as shown in Figure 6.

The dried ADU is crushed in a cone-type mill and loaded into Inconel or Hastelloy-C trays. These trays are introduced into a box of the same material which fits into an electric muffle furnace as shown in Figure 7.

Air is swept from the box with a nitrogen stream and a mixture of steam and ammonia introduced. The temperature is increased to 1,470° F. and the ammonia flow is continued at this temperature until reduction is complete. The box is withdrawn from the furnace, cooled to essentially room temperature with a water spray, and the product removed. This step involving simultaneous pyrohydrolysis and reduction is used only for the larger scale low enrichment batches. High enrichment batches are pyrohydrolyzed and reduced in separate operations. The steam cycle is stopped before the ammonia is introduced, and the ammonia is cracked before introduction into the box, in the case of high enrichment batches.

The UO_2 is removed from the trays and milled again in a cone mill. If the brown oxide is to be fabricated into ceramic fuel elements, it is ready for shipment at this point. For some purposes, such as inclusion in a stainless steel matrix fuel element, a high fired product is desired. For this purpose, after the reduced product is crushed, it is introduced into molybdenum trays and fired for 4 hr. at 3090° F. in a molybdenum wound resistance furnace. After milling, the product is screened and the minus 200 mesh plus 325 mesh fraction is used for fuel element production. The oversize from this screening operation is recycled to the mill and the fines returned to the high firing operation.

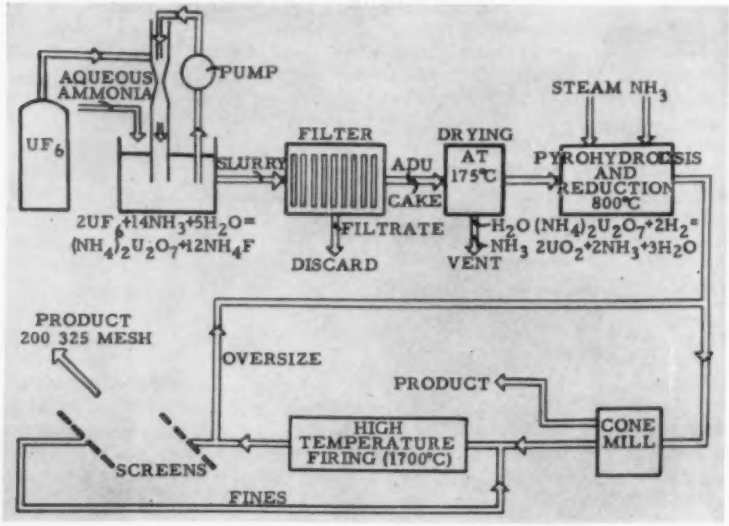
Table 2 shows an analysis of the type of product from this process. It is possible that if sufficient demand existed, the amount of some of these impurities could be considerably decreased. Note that the tap density of the ceramic-type product may be controlled at will over the range of 1.5 to 5.0 g./cc. for any special application. The particle size of the product may also be controlled.

Because of the great value of highly enriched uranium, it is necessary to avoid all losses. All work with high enrichments is carried out in dryboxes that permit recovery of all dust. A panoramic view of the area in which high enrichment material is processed is shown in Figure 8. Here the drybox-type operation, the wide separation of the units, and the standards of cleanliness required for this type of operation can be seen.

Table 2.—Composition of ADU Type UO_2

Composition	$UO_{2.000}$–$UO_{2.016}$
Ni	70 p.p.m.
F	100–300
Fe	60
Cr	30
B	0.2
Cu	10
Si	50
Ag	0.1
Sn	1
Pb	2
Tap density	1.5–5.0 g./cc.
Mean particle size	0.5–2μ

Fig. 4. ADU flow sheet.



UO_2 by Other Methods

A variety of other methods has been studied on an experimental or semiworks scale, but none has been put into large-scale plant practice. Since some of these methods produce a UO_2 of high surface area and very good sinterability, it seems possible that one or more of these may be developed on a commercial basis in the future. Similar considerations apply to variations in the methods described above.

For example precipitants other than aqueous ammonia, such as urea, ammonium carbonate, and ammonium oxalate have been studied (*11*). These could be applied to nitrate, fluoride, or

other uranium solutions. Hydrogen peroxide precipitation is a classical method of uranium separation, and thermal decomposition of the resulting peruranate has also been studied.

Air oxidation of metal, UH_3, or of UO_2 itself to U_3O_8, as well as thermal decomposition of UO_3 to U_3O_8, followed by hydrogen reduction in the usual manner have led to variations in the properties of the resulting UO_2. It has also been found that hydrogen reduction of the various crystal forms of UO_3 proceeds at different rates and results in UO_2 of different properties. Type II UO_3, for example, reduces more readily and gives a more sinterable product than Type III (pot denitrated) UO_3. Hydrogen reduction of UO_3 monohydrate is of special interest because of its use in growing large particles to give large, dense UO_2 particles.

Contrary to most methods, the oxidation of uranium metal with high pressure steam (2,200 lb./sq.in. gauge, 650° F., 24 hr.) is reported (*11*) to produce a slightly oxygen deficient UO_2. The product, however, shows no particular advantage in properties, and it is doubtful whether going through the metal step can be justified economically.

Grinding UO_2 improves its sinterability quite markedly. This is presumably due primarily to an increase in surface area and a reduction of the number of closed pores, allowing the material to be more easily compacted into a continuous mass. It appears that adequate grinding practice may yield powders as readily sinterable as are obtained by the precipitation methods mentioned above. Certain other oxides, such as TiO_2, added to the UO_2 before sintering also improve the density of the compacts (*12*). The relative costs of the various routes to produce a powder of suitable properties are not yet determined with sufficient accuracy to predict the method of ultimate choice.

A novel preparation method based on the fact that UO_2 is the stable oxide above about 2,400° F., has recently been developed at the AEC plants in St. Louis. This technique uses either a high temperature hydrogen or methane flame or an atomic hydrogen arc to attain the temperature necessary to fuse UO_2. The general objective is to obtain UO_2 of extremely high density, often approaching the theoretical x-ray density of 10.97 within the limit of measurement. Although this method may eventually be used for the production of solid fuel elements directly, it is mentioned here as a method of production of uranium dioxide since this can be a direct step from uranium tri-

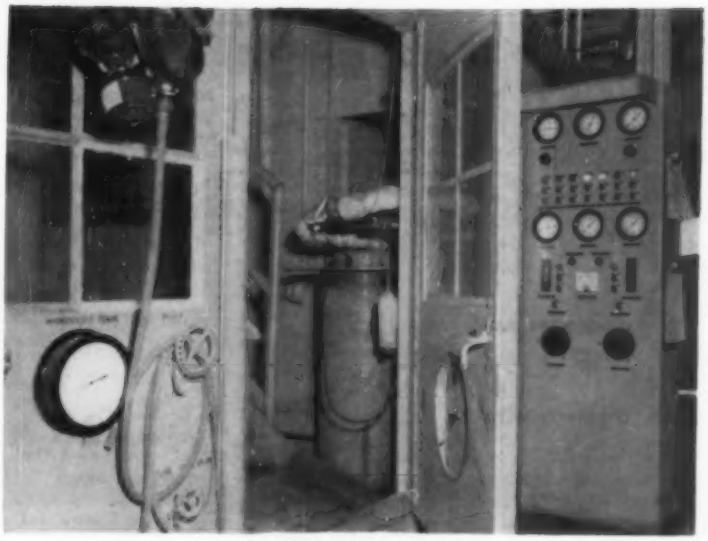


Fig. 5. Hydrolysis equipment.

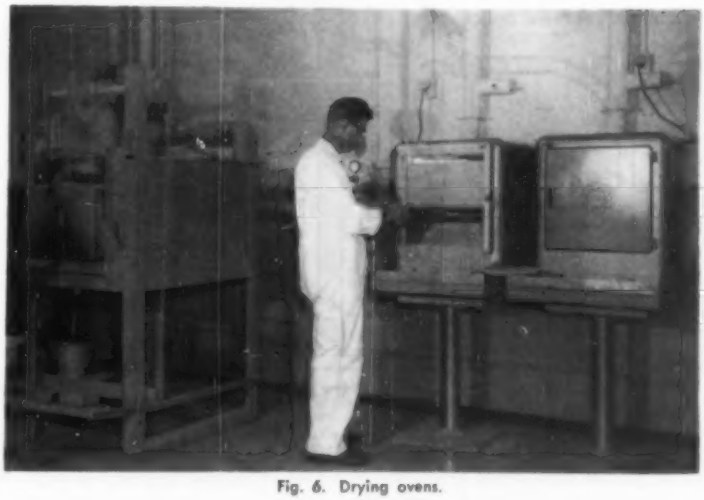


Fig. 6. Drying ovens.

Fig. 7. Muffle furnace.

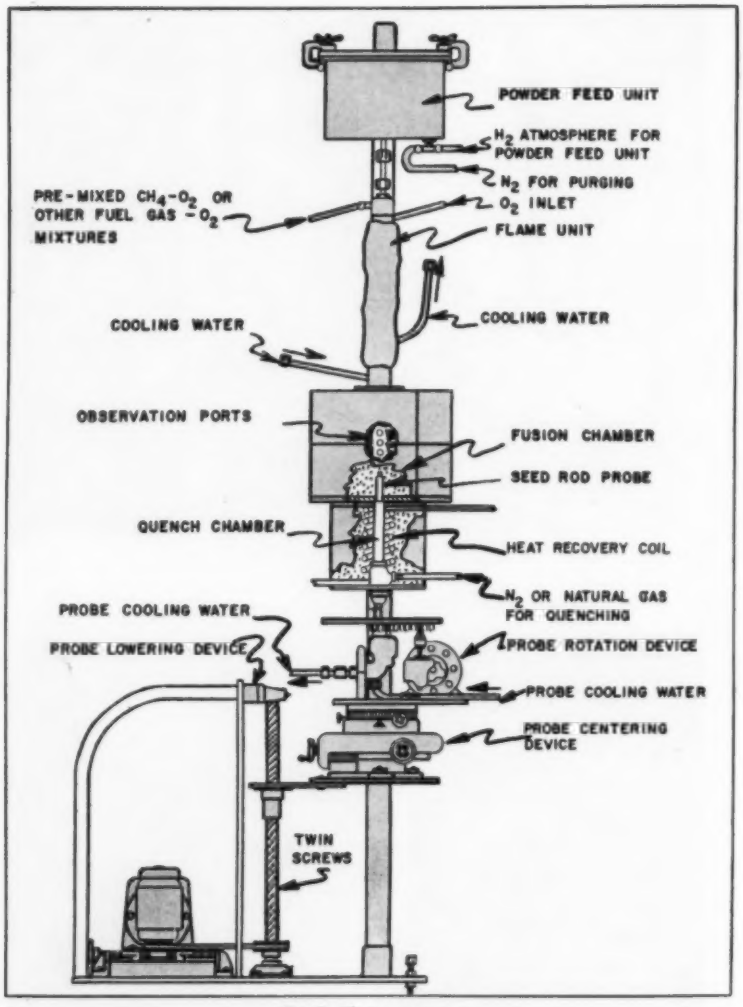


Fig. 9. Flame reactor.

oxide or uranyl nitrate with the dioxide in powder form never appearing as an intermediate. Figure 9 shows the general arrangement of a flame fusion apparatus.

In the use of this equipment, the feed material (uranium trioxide powder, uranyl nitrate solution, or even uranium dioxide powder where only further densification is wanted) is fed through a tube directly onto the top of some already fused uranium dioxide which is maintained in the hottest part of the flame by the drive mechanism which continuously lowers the rod, or boule, of fused uranium dioxide as it forms. The solidified rod which is obtained by this method is polycrystalline, but the individual crystals are fairly large in size (1-5 mm.). It is believed that if such material were used in a fuel element it would have a decided advantage in heat transfer over compacted and sintered powders which have very small crystallite sizes. It is also possible to grind the fused material to give a coarse powder of very high density for use in cermet-type fuel elements.

In various experimental runs uranium dioxide closely approaching $UO_{2.00}$ has been made starting from the trioxide, the nitrate, and from the powdered dioxide. The mechanical control necessary for the growth of large, single crystals has not yet been perfected, but it is believed that this will be an interesting outcome of this technique.

In concluding it may be interesting to compare the appearance of UO_2 produced by the present commercial methods, as shown by some excellent electron micrographs from a recent Hanford report (*13*) (Figure 10).

The marked difference both in size and surface texture of particles of the two materials serves to explain the observed differences in their sinterability.

Acknowledgment

We wish to acknowledge that the ADU process was developed by the Special Metals Division of Mallinckrodt Chemical Works under the supervision of F. M. Belmore. The remainder of this report is based on work by personnel of the Uranium Division, too numerous to cite individually.

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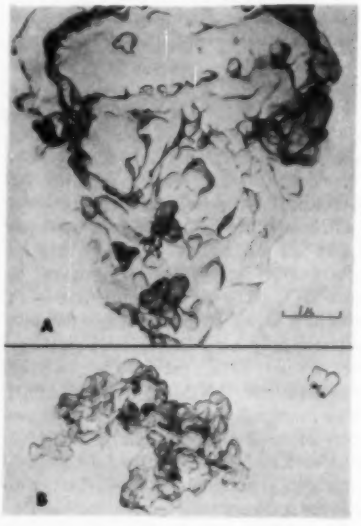
Fig. 10. Electron micrographs of UO_2 powders by (A) UO_2 method; and (B) ADU method.



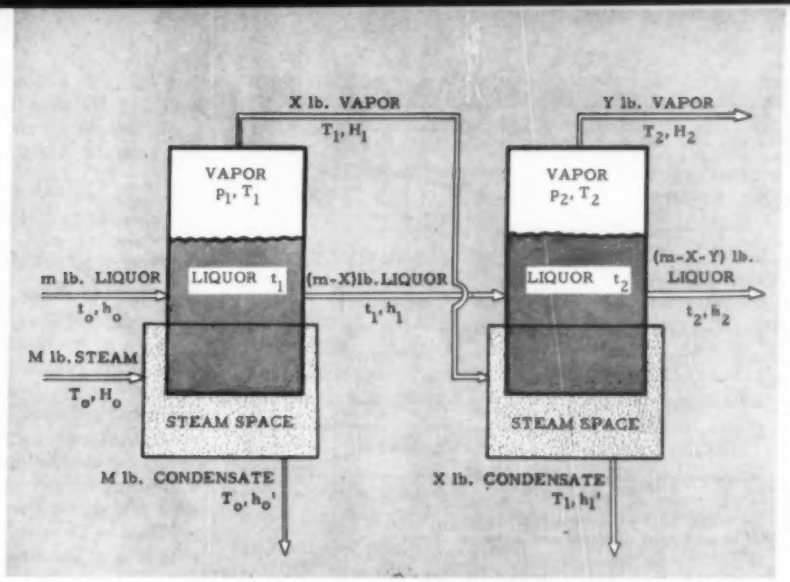


Fig. 1. Two evaporators with forward feed.

MULTIPLE-EFFECT EVAPORATOR CALCULATIONS

The accompanying article describes a means for permitting a more ready acceptance of up-to-date computer techniques in a determination of the number of stages for multiple-effect evaporation.

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In finding the number of stages for multiple-effect evaporation the usual practice is to proceed by trial-and-error methods or by experience (*1-5*), for the number of variables involved is usually large and the effect of many of them is often unknown.

Nevertheless, it is possible in principle to calculate exactly the optimum number of stages, steam consumption, etc., and although the calculations may sometimes appear laborious, the work can be reduced by using modern computing machines. In addition, calculations from first principles further the understanding of the process. It is felt that this is particularly valuable in problems involving many variables where too much reliance is often placed on trial-and-error methods, and it is hoped that the calculations on multiple-effect evaporation presented below will encourage reducing trial and error to a minimum.

Basic Equations

The case of two evaporators in series with forward feed will be considered. The arrangement is shown in Figure 1.

A heat balance on the two stages gives the following equations:

1st effect:

$$q_1 = M(H_o - h_o') = m(h_1 - h_o) + X(H_1 - h_1) = k_1A_1(T_o - t_1) \quad (0a)$$

$$\therefore M(H_o - h_o') = k_1A_1(T_o - t_1) \quad (1)$$

$$\text{and } X = \frac{k_1A_1(T_o - t_1) - m(h_1 - h_o)}{H_1 - h_1} \quad (2)$$

2nd effect:

$$q_2 = X(H_1 - h_1') = (m - X)(h_2 - h_1) + Y(H_2 - h_2) = k_2A_2(T_1 - t_2) \quad (0b)$$

$$\therefore X = \frac{k_2A_2(T_1 - t_2)}{H_1 - h_1'} \quad (3)$$

$$\text{and } Y = \frac{k_2A_2(T_1 - t_2)(H_1 - h_1' + h_2 - h_1) - m(H_1 - h_1')(h_2 - h_1)}{(H_1 - h_1')(H_2 - h_2)} \quad (4)$$

In addition, if the total amount of evaporation is fixed, then

$$X + Y = E = \text{constant} \quad (5)$$

Equations (1)-(5) are basic and from them the heat duty, amount of evaporation in each effect, and the product (heat transfer coefficient X area) can be found.

Thus, from (3), (4), and (5)

$$E = k_2A_2\frac{(T_1 - t_2)(H_1 - h_1' + H_2 - h_1)}{(H_1 - h_1')(H_2 - h_2)} - \frac{m(h_2 - h_1)}{H_2 - h_2}$$

$$\therefore k_2A_2 = \frac{(H_1 - h_1')(H_2 - h_2)}{(T_1 - t_2)(H_1 - h_1' + H_2 - h_1)}\left(E + m\frac{h_2 - h_1}{H_2 - h_2}\right) \quad (6)$$

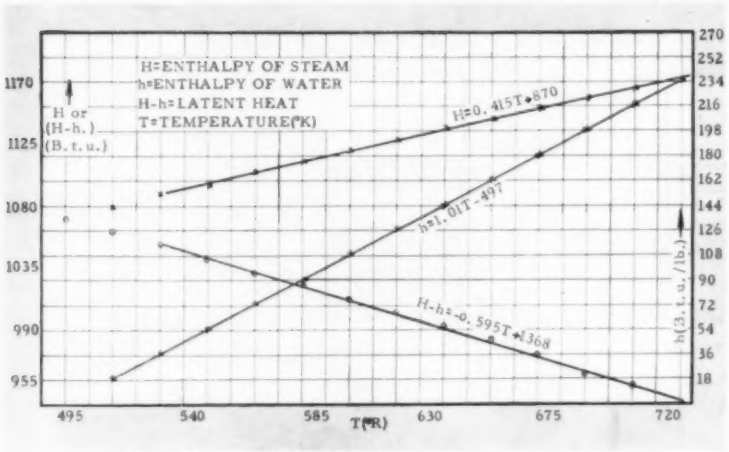


Fig. 2 Plot of enthalpies of steam and water vs. temperature.

From (2) and (3)

$$k_1A_1 = \frac{H_1 - h_1}{T_o - t_1}\left[k_2A_2 \frac{T_1 - t_2}{H_1 - h_1'} + m \frac{h_1 - h_o}{H_1 - h_1} \right]$$

$$= \frac{H_1 - h_1}{T_o - t_1}\left[\frac{H_2 - h_2}{H_1 - h_1' + H_2 - h_1} E + m\left(\frac{h_2 - h_1}{H_1 - h_1' + H_2 - h_1} + \frac{h_1 - h_o}{H_1 - h_1} \right) \right] \quad (7)$$

and from (1)

$$M(H_o - h_o') = (H_1 - h_1)$$

$$\left[E \frac{H_2 - h_2}{H_1 - h_1' + H_2 - h_1} + m\left(\frac{h_2 - h_1}{H_1 - h_1' + H_2 - h_1} + \frac{h_1 - h_o}{H_1 - h_1} \right) \right] \quad (8)$$

From (3) and (6)

$$X = \frac{H_2 - h_2}{H_1 - h_1' + H_2 - h_1}\left(E + m \frac{h_2 - h_1}{H_2 - h_2} \right) \quad (9)$$

and from (4) and (6)

$$Y = E\left(\frac{H_1 - h_1' + h_2 - h_1}{H_1 - h_1' + H_2 - h_1} \right) - m\left(\frac{h_2 - h_1}{H_1 - h_1' + H_2 - h_1} \right) \quad (10)$$

Equations (6)-(10) give design variables in terms of enthalpies and temperatures. The enthalpies in turn are functions of temperature and liquor composition.

For example, in the first evaporator the enthalpy of the liquor h_1 depends on the temperature t_1 and, in general, the liquor composition; and the enthalpy of the vapor H_1 depends on the temperature T_1.

To find the heat available for the next effect, the temperature in the vapor space T is usually taken to be the temperature of the saturated vapor at the appropriate pressure (p). For, although the vapor leaves the liquid superheated at the temperature t, if there is a boiling-point elevation, the superheat is usually lost quickly and the heat available for the following evaporator is that of the saturated vapor. On the other hand, to find the heat necessary to raise a given amount of vapor, T must be taken equal to the liquor temperature.

Regarding the independent variables in terms of which the other quantities are expressed: if the pressure in the vapor space p is given, then T, the temperature of the saturated vapor is known, and if the composition of the liquor is also given, then t is known. Thus, the independent variables are vapor pressure p and liquor composition. Alternatively, T can be used instead of p and if it is assumed that only one component is evaporated, then since t is a function of composition and T, the independent variables can be taken to be T and t. This is more convenient since the enthalpies can often be expressed more simply in terms of temperature. Thus, if there are n effects, there will be $2n$ independent variables in the equations corresponding to (6)-(10), namely t and T for each evaporator. This assumes that T_o, t_o, E, and m are given, which is usually the case in practice.

The optimum conditions depend on the cost of steam, represented by $M(H_o - h_o')$, and the capital and maintenance charges which are based on the total heat transfer area

$$A_1 + A_2 + \ . \ . \ + A_n.$$

The sum of these costs must be a minimum.

For a given number of effects the result of the calculations will be to find optimum steam usage, heat transfer area, etc., and simultaneously to determine optimum operating conditions. When the calculations are repeated for a different number of effects, it is possible to compare the relative merits of, say, two or three such effects.

It is clear that the greater the number of effects, the greater is the number of independent variables and the more time consuming the calculations. In addition, it is necesary, in general, to know the enthalpy of the liquor as a function of the temperature and composition. Nevertheless, in a number of cases it is possible to simplify the problem considerably.

As an example, calculations are presented for a simple case of double-effect evaporation.

Calculations

SIMPLE CASE OF DOUBLE-EFFECT EVAPORATION

It is assumed that the enthalpy of the liquor is substantially the same as for water and that it has no boiling-point elevation.

The liquor is used in some process which it leaves at 113° F. and is to be returned to this process after 14% evaporation at the same temperature of 113° F. without heating or cooling. The steam temperature to the first effect is taken as 266° F.

Calculations are based on a feed of 1 lb. of liquor/hr.

Thus, $m = 1$ lb./hr.
$E = 0.14$ lb./hr.
$t_1 = T_1$ and $t_2 = T_2$
$T_o = 266°$ F.
$t_o = 113°$ F.
$t_2 = 113°$ F.

Further, if the enthalpies of steam and water are plotted vs. temperature (see Figure 2), it is found that the relations are practically linear at least in the range 68-266° F. In fact if T is the absolute temperature (° R.) then

$$H = 0.415\ T + 870 \text{ B.t.u./lb.}$$
$$h = 1.01\ T - 497 \text{ B.t.u./lb.}$$
$$H - h = -0.595\ T + 1{,}367 \text{ B.t.u./lb.}$$

With these equations and the figures given above, then from (8)

$$M(H_o - h_o') = \frac{1.02\ T_1^2 - 2108\ T_1 + 700{,}000}{1.61\ T_1 - 2{,}970} \quad (11)$$

Figure 3 (*i*) shows the plot of Equation (11). For steam at 266° F., $H_o - h_o' = 520$, and the ordinates divided by 520 will give the pounds of steam required per pound of liquor.

Substituting numerical values in Equation (7),

$$k_1A_1 = \frac{-1.02\ T_1^2 + 2{,}291\ T_1 - 713{,}000}{1.61\ T_1^2 - 4{,}137\ T_1 + 2{,}150{,}000} = \frac{(1.02\ T_1 - 381)(1{,}871 - T_1)}{(725 - T_1)(2{,}970 - 1.61\ T_1)} \quad (12)$$

and from (6)

$$k_2A_2 = \frac{0.6\ T_1^2 - 1{,}810\ T_1 + 987{,}000}{-1.61\ T_1^2 + 3{,}890\ T_1 - 1{,}700{,}000} \quad \frac{(1{,}368 - 0.595\ T_1)(723 - 1.01\ T_1)}{(T_1 - 573)(2{,}970 - 1.61\ T_1)} \quad (13)$$

It should be noted that in Equations (11)-(13) T_1 is the absolute temperature (° R.)

As may be expected from physical considerations, $k_1A_1 \to \infty$ when $T_1 \to 725°$ R. (266° F.) and $k_2A_2 \to \infty$ when $T_1 \to 573°$ R. (113° F.). Also $k_2A_2 = 0$ when $T_1 = 716°$ R. (257° F.). This means that the heat content of the liquor coming from the first effect is sufficient to give the required evaporation in the second effect at a vacuum corresponding to $T_2 = 113°$ F., and without any further heat transfer from the first-effect vapor.

Figure 3 shows k_1A_1, k_2A_2 and $k_1A_1 + k_2A_2$ as functions of T_1.

From (10), the vapor load on the condenser is

$$Y = \frac{0.785\ T_1 - 170}{-1.61\ T_1 + 1{,}650} \quad (14)$$

From (11)-(14) the optimum conditions are found as follows: the cost of steam is proportional to M, i.e., cost of steam $= KM$

The charges arising from depreciation, repairs, and maintenance are a function of the total heat transfer area. Thus,

Charge $= f_1(A_1 + A_2)$

The cost of condenser and cooling medium is a function of Y, say,

Cost of condenser $= f_2(Y)$

Then total cost $C = KM + f_1(A_1 + A_2) + f_2(Y)$ (15)

A_1 and A_2 are found from (12) and (13) and a knowledge of the heat transfer coefficients in terms of T_1.

Then the total cost in the present case is a function of T_1 only and (15) becomes

$C = f(T_1)$

For a minimum

$$\frac{dC}{dT_1} = 0 \quad (16)$$

This determines T_1, and hence A_1, A_2, M, and Y are found from (11)-(14).

To take a numerical case, suppose that the following data are known from previous experience.

Liquor feed rate = 100,000 lb./hr.
Heat transfer area = 1,650 sq.ft.
= 0.0165 sq.ft./(lb. of liquor)/(hr.)

Total installation cost = \$100,000 = \$1.00/lb. of liquor/hr.

Heat transfer coefficient k_1 = 250 B.t.u./(sq.ft.)(hr.)(° F.)

Heat transfer coefficient k_2 = 100 B.t.u./(sq.ft.)(hr.)(° F.)

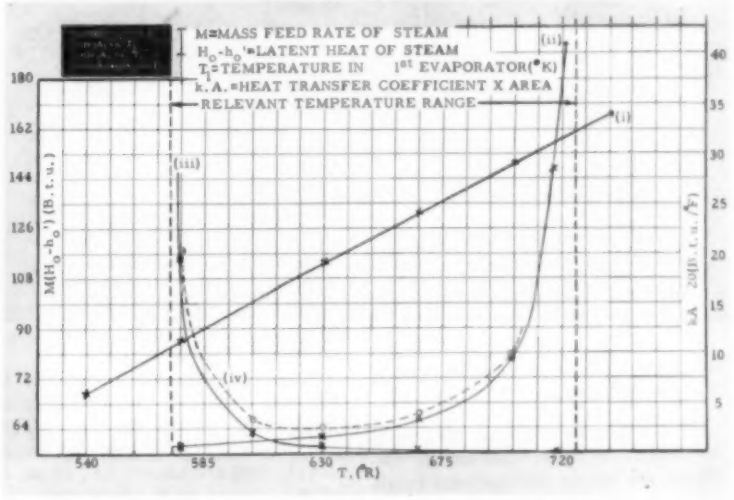
Cost of steam = \$0.77/1,000 lb.

The installation cost for A sq.ft. of heat transfer area is calculated according to the so-called "⅝th power rule" as

$$\$\frac{100{,}000}{100{,}000} \times \left(\frac{100{,}000\ A}{1{,}650}\right)^{5/8} = \$\left(\frac{A}{0.0165}\right)^{5/8}$$

Depreciation is calculated at 6⅔%/yr., and repairs and maintenance at 12½%/yr., giving a total charge of 19.17%/yr.

Fig. 3. Two evaporators in series. (i) $M(H_o - h_o')$ vs. T_1, (ii) k_1A_1 vs. T_1, (iii) k_2A_2 vs. T_1, (iv) $k_1A_1 + k_2A_2$ vs. T_1.



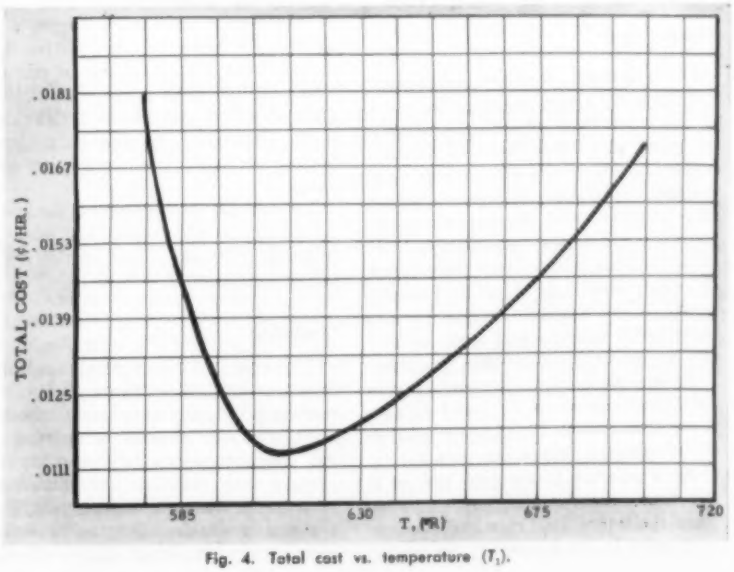


Fig. 4. Total cost vs. temperature (T_1).

In the present example, neglecting condenser costs

Total charge of depreciation, repairs, and maintenance.

$$= \frac{19.17}{100} \times \left(\frac{A_1 + A_2}{0.0165}\right)^{5/6} \times \frac{1}{365 \times 24} \text{ \$/hr.}$$

Cost of steam in ¢/hr. $= 0.0833M$

$\therefore$ Total cost C in ¢/hr. $= 0.0833M + 0.0284(A_1 + A_2)^{5/6}$ (17)

Figure 4 shows how the total cost varies with T_1. Either from the figure or by differentiation of (17) with respect to T_1, it is seen that C is a minimum when

$T_1 = 611°$ R. approximately
$= 152°$ F. approximately

Then from Figure 3, or from (11)-(13),

$$A_1 = \frac{k_1 A_1}{250}$$

$= 0.005$ sq.ft./(lb. of liquor)/(hr.).

$$A_2 = \frac{k_2 A_2}{100}$$

$= 0.0125$ sq.ft./(lb. of liquor)/(hr.).

$$M = \frac{M(H_o - h_o')}{520}$$

$= 0.112$ lb./hr.

and from (14), $Y = 0.088$ lb./(hr.)/(lb. of liquor).

Thus the steam required, heat transfer areas, and vapor load on the condenser are known for optimum conditions.

GENERAL CASE

In the general case for n evaporators there is a set of relations like (0a) or (0b) for each effect. Every such set gives two equations and in each evaporator there are two independent variables or degrees of freedom which may be taken to be the liquor concentration c and liquor temperature t. If these two are given, then the amount of evaporation, e.g., X or Y, and also p and T are known. Instead of c, t some other suitable pair such as T, t can be chosen as independent variables.

Boiling-point elevation curves give the relation between T, t, and c; also, if the temperature T is known, then so is the saturated vapor pressure p.

As a rule the liquor feed rate m to the first evaporator is known. Then from the liquor feed rate and the concentration in the first effect, the amount of evaporation X can be calculated. Similarly the amount of evaporation in the second and subsequent evaporators are known when the concentrations are given.

For example, let the concentration c denote the pounds of water per pound of liquor. Then the inlet concentration is c_o, the outlet concentration (which is taken equal to the concentration in the 1st effect) is c_1.

$$\therefore mc_o = (m - X)c_1 + X$$

or

$$X = \frac{m(c_o - c_1)}{1 - c_1}$$

Thus, all the relevant variables for n evaporators can be expressed in terms of $2n$ independent variables, and in general, the cost C will be a function of $2n$ independent variables.

The sequence of calculations is then as follows:

Express M and the heat transfer area A in terms of the enthalpies, inlet conditions, and total amount of evaporation as in (6)-(8).

Find the enthalpies in terms of the independent variables.

The total cost C is found as a function of M and the A and hence of the independent variables.

The expression for C is differentiated partially with respect to each independent variable and the result equated to zero. This gives $2n$ equations for finding the $2n$ variables for a minimum C, if this exists.

After the independent variables for optimum conditions have been obtained they are substituted into the equations for M, A, etc., and thus the desired design data are known, i.e., steam required, size of evaporators, etc.

When the calculations are repeated for a different number of stages, it is possible to decide on the relative advantages of various numbers of effects.

In principle it is possible to extend the method of calculation to take account of vapor recompression, preheating of liquor feed, and other variants.

The amount of arithmetical work involved in the calculations will make it desirable in many cases to use computing machines.

Conclusion

To carry out exact design calculations as outlined in this article, it is necessary to know heat transfer coefficients and the physical properties of the liquors used, e.g. boiling-point elevations with different concentrations. In a great many cases sufficient data are not available. But, as scientific data accumulate, exact design calculations will become increasingly worthwhile, especially if aided by computers to cut down the more laborious calculations.

Naturally the reliability of the results in the present case will be of the same order as the reliability of the initial data and the validity of equations such as (0a).

Summary

Methods are given for exact calculations on multiple effect evaporation for design purposes. It is shown how heat transfer area, steam requirements, vapor load on the condenser and other items can be calculated from first principles.

The data required to make such calculations are defined, i.e. in addition to heat transfer coefficients, curves of boiling point elevation for different concentrations, pressure - temperature relation of the saturated vapor and enthalpies as functions of the independent variables.

The minimum total cost of a plant is found. This includes operating costs, depreciation, repairs and maintenance. From this the optimum operating conditions are determined and hence the design variables can be calculated.

Acknowledgment

The above work was done while the author was a member of the Research Department of Courtaulds, Ltd., Coventry, and the directors' permission to publish this article is gratefully acknowledged.

Notation

A subscript or superscript is used to distinguish symbols relating to different effects.

- m = mass feed rate of liquor
- M = mass feed rate of steam
- E = total evaporation rate
- X, Y = mass rate of evaporation in different effects
- t = liquor temperatures
- T = vapor temperatures
- p = pressure in vapor space
- h = enthalpy of liquid or condensate
- H = enthalpy of vapor
- c = liquor concentration
- k = over-all heat transfer coefficient
- q = heat transfer rate
- A = heat transfer area
- C = total cost
- K = proportionality constant

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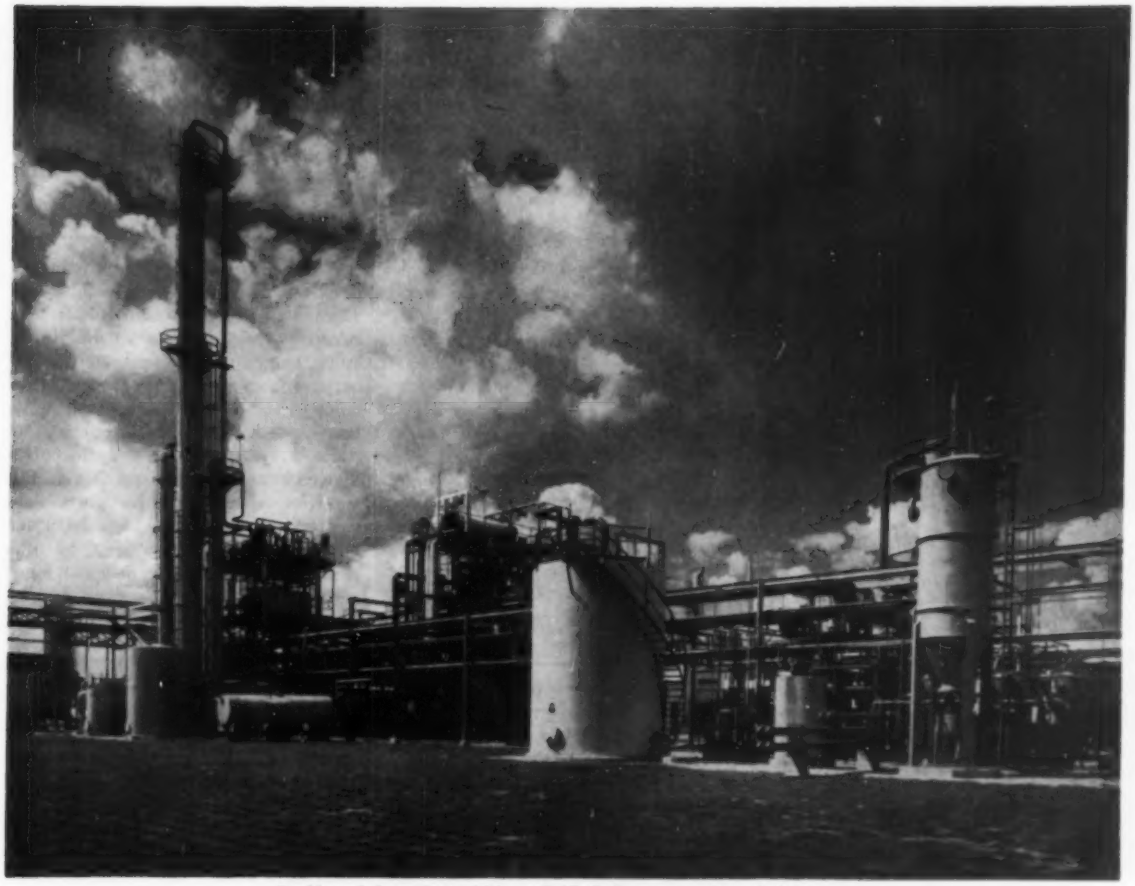

Perchloroethylene plant of Diamond Alkali Company at Deer Park, Texas

CASE HISTORY

the development of a perchloroethylene process

Highlights of the development of a process for perchloroethylene are traced from the early exploratory period. In contrast to the technical aspects of the work, this account emphasizes program planning, cost distribution, and manpower requirements.

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As part of a program for diversification and expansion, the Diamond Alkali Company undertook the development of a process for making perchloroethylene. Perchloroethylene was of great interest since it had growth potential, fitted well the company's position in carbon tetrachloride sales, and required chlorine, one of the materials for which expansion plans had been laid.

Through contacts in its national sales outlets, the company was able at an early date to foresee the demand for the product. Hence, no additional effort in the form of highly formalized market research was necessary. On the other hand, it was recognized that many other matters had to be given thorough and detailed consideration. These are the following:

1. Relevant patents
2. Organic raw materials
3. Process alternates
4. Plant location
5. Product quality
6. By-products

Preliminary

Responsibility for a study of these subjects was placed in the hands of the Research and Development Department where a nucleus of chemists and engineers assisted by patent counsel was organized to handle the work. Beside the specific objectives of developing process and product information, it was the intention to use the project to build some of the background required by the company for other organic operations. Accordingly, it was expected that some phases of the work would be explored more widely than would be required under normal circumstances. Responsibility for the project remained in the Research and Development Department and it was expected that some men involved in the development would provide experienced personnel required later in commercial operation.

Exploratory

Exploratory effort was begun in 1945. Objectives of this phase of the work were to answer the questions—

1. What is the most economical organic raw material feed?
2. Is it preferable to develop the process or to attempt to buy the necessary information?

Information and patent searches were supplemented by laboratory investigations which covered both reported techniques and alternate proposals suggested by the research and development personnel. Economic evaluations were developed to orient thinking on the relative merits of various organic feed materials. Process variations and changes in capital requirements dictated by various feeds were weighed. Acetylene, mixed olefins, pure ethylene, saturated hydrocarbons, and carbon tetrachloride were considered. The latter—which can be converted to perchloroethylene by pyrolysis—was particularly interesting since Diamond was established in the manufacture of this product.

By early 1946 there was convincing evidence that the company should undertake its own development of a process and that the process should be based on the use of an olefin feed. Though carbon tetrachloride offered a relatively quick path to a plant installation and as a starting material was an available company product, this route proved to have no long-range attractiveness. Similarly, the acetylene route was turned down only to be reviewed later when an available acetylene-route war surplus plant was considered. However, the possibilities for quickly entering the field by this method could not offset its poor long-range possibilities.

Pilot

Sufficient information had now been obtained to justify small-scale pilot work and to consider product quality requirements. With broadening of the program, the staff was enlarged. Experimental work was started to—

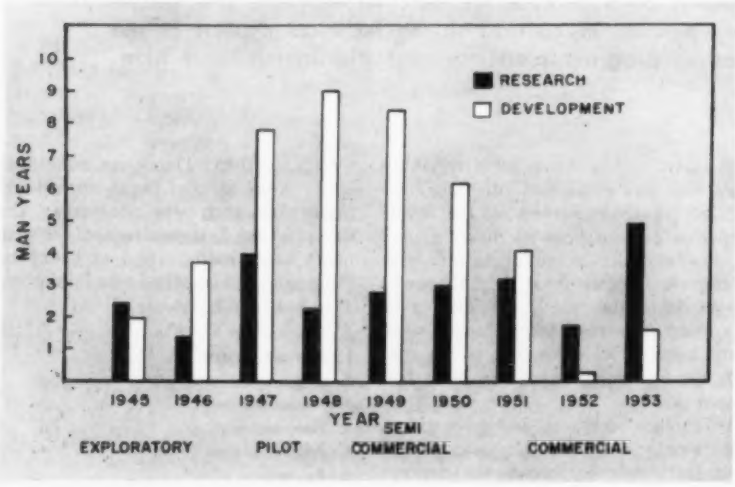
1. Evaluate several types of olefin feed materials.
2. Evaluate chlorine purity requirements.
3. Evaluate alternate processing methods.
4. Make quantities of perchloroethylene needed for quality evaluation and quality improvement studies.

In the study of olefin raw materials, consideration was given to coke-oven gas, crude cracked gases, and purified ethylene. Economic evaluations strongly indicated that the direct use of crude gas obtained from the cracking of propane should be thoroughly investigated. Thus a small-scale propane cracker was installed to furnish sufficient gas for pilot studies. As it became evident that an outside source of relatively pure ethylene could be available, bench scale work was done with higher quality ethylene. All through the evaluation of olefinic feed materials and the various processing techniques, chlorine purity requirements were carefully studied.

Since raw materials are the major cost in making perchloroethylene, the process evaluations were largely influenced by the specific raw materials. It was necessary to evaluate catalytic, thermal, chemical dehydrochlorination, and light activated techniques. The merits of anhydrous vs. wet systems, single step vs. multistep operations, and semibatch vs. completely continuous methods were considered. Throughout this phase of the work, repeated guidance was provided in the form of numerous raw material and equipment estimate evaluations.

The pilot stage covered a period of two and one-half to three years. By the beginning of 1948, the elements of a practical design were being assembled. The design involved the use of high quality ethylene to prepare ethylene dichloride. This would be chlorinated to higher intermediates which, in turn, would be dehydrochlorinated to produce perchloroethylene and by-product hydrogen chloride. The process was essentially continuous. As work of the pilot period neared completion, the possible value of fluidized reactor techniques was recognized, and an experimental study was made part of the program. Results indicated that incorporating a fluidized reactor into the design might simplify the planned multistage operation and minimize raw material quality requirements. However, the time scheduled for introductory sale of the perchloroethylene could not be met if the fluid unit were to be first completely evaluated. It was decided, therefore, to proceed with the information on hand and, as a possible alternate, to continue pilot work on the fluidized technique.

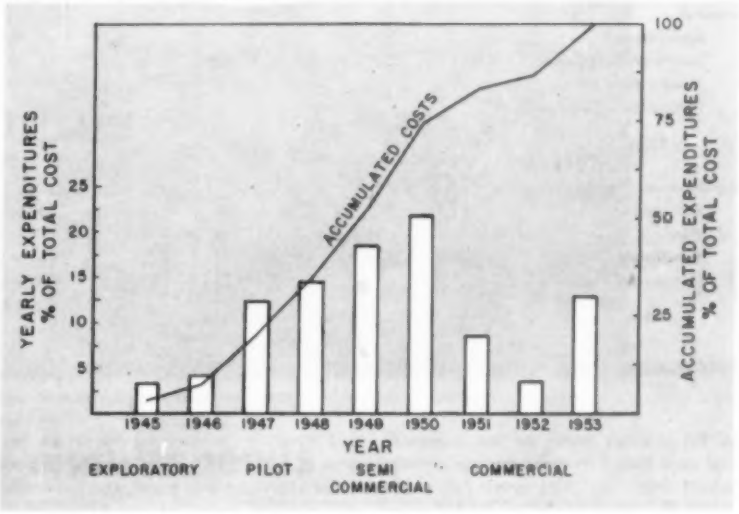
Fig. 1. Research and development manpower.



Semicommercial

Shortly a decision whether to proceed on a semicommercial or a full commercial basis was required. The elements of timing and of over-all cost had to be kept in mind. For the first time, it became highly important seriously to think about possible plant sites. Diamond's new multimillion dollar chlorine-caustic plant in the growing industrial area of Houston provided a relatively simple and logical choice of plant location. With low-cost ethylene becoming available in the area, chlorine available from its new installation, favorable possibilities for expansion, and with a potential outlet for anhydrous by-product hydrogen chloride, the Houston site was a natural selection. Instead of proceeding directly to a full-scale operation, it was decided that a semicommercial unit should first be installed. The relative cost risk involved in the two alternates was difficult to evaluate. It was felt, however, that the semicommercial operation would provide the quickest means of entering the field consistent with best assurance of success.

Fig. 2. Research and development costs.



Detailed design of the semicommercial unit was done by development engineers, and the installation at the Houston location was directed by development personnel. Development people were also put in charge of the operation which began in early 1949. In the initial operations, several serious problems relating to capacity and corrosion were brought to light. After about two months of slow progress, it became questionable whether the added effort necessary to make the multistage process work was worthwhile. By this time, work on the fluidized unit had convincingly demonstrated its value. With sufficient data for design, it was decided to abandon parts of the old process and include the fluidized reactor into an improved design. An estimated three to four additional months' delay was expected, but the indicated simplifications and improvements justified the change.

Early tests of the modified unit confirmed that the design was basically sound. Nevertheless, product quality did not meet the standards established in the pilot work and operations were hampered by equipment problems normally encountered in a new installation. The difficulties with equipment were gradually eliminated, but product stability remained a perplexing problem for about a half year. Investigation showed that the difficulty was caused by a combination of several factors, including the substitution of a material of construction not used in the pilot plant and a seemingly unimportant change in stabilizing technique. The difficulty was soon remedied and enough good quality product became available to begin sales in mid-1950. By centering attention upon plant operations, sustained performance was soon attained. By early 1951, day-in-day-out operation was in effect and by mid-1951, control of operations was transferred to the manufacturing department, although research and development personnel maintained contact with the work.

During the early commercial period, a high percentage of good quality material was produced, but raw material efficiencies lagged significantly behind what had been initially predicted. Detailed examination of the operation showed that further equipment improvements and process modifications would result in greater efficiency. In fact, many valuable improvements subsequently incorporated into the full commercial design by the operating and engineering groups led to efficiencies well beyond any of the research and development predictions.

Product Evaluation and Improvement

From the early part of the exploratory work, attention was given to commercial requirements and to the establishment of tests for evaluating the perchloroethylene. It was recognized from the start that a stabilizing additive would have to be provided to maintain product quality when the material is subject to practical use. General sources of information provided a number of supposedly suitable additives. Furthermore, the company was selling a top grade of carbon tetrachloride for many years without finding it necessary to add stabilizers—minute traces of material left in the carbon tetrachloride are now recognized as having stabilizing value.

Commercial requirements and test information were obtained to a limited extent from published sources. However, the most valuable information was given by a leading producer of dry-cleaning equipment and that obtained by testing commercial materials in the company laboratories. When product became available from the pilot units, laboratory work was started to test a number of additives.

When weaknesses of the initially selected stabilizers began to appear, greater emphasis was given to this phase of the program. A relatively large number of proposed stabilizing materials were screened. The most promising of these were then subjected to conditions closely resembling those expected under commercial use. By the time that the semicommercial unit was built, a stabilizer had been developed which gave results equal or superior to competitive materials. No attempt was made to test this pilot material in the field. It was felt to be to the company's best interest to have commercial quantities available before the product was open to examination by others. As previously indicated,

Table 1.—Distribution of Research and Development Work

	Approximate man years	% of total cost
Research		
Exploratory	7	6
Stabilizer development	10	11
Product field testing	5	8
Commercial improvement	4	6
Totals	26	31
Development		
Exploratory	4	3
Pilot	14	15
Semicommercial	23	48
Commercial improvement	1½	3
Totals	42½	69

initial product from the semicommercial unit failed to meet the quality obtained from the pilot work but eventually did when suitable changes were made. It was now understood that stability work was best done in close contact with plant operations and, accordingly, the major portion of the work was transferred to the plant location. Valuable contributions continued to be made by those in the research laboratories who directed subsequent field testing.

Field tests on the material initially commercialized, made in both drycleaning and degreasing units, became an important part of stabilizer evaluation. From this work and continuing effort on stabilizer development, perchloroethylene of the highest quality is being provided.

Initial Commercial

With soundness of the semicommercial unit demonstrated, it was decided to expand the operations to an economically attractive production level. Responsibility was placed in the hands of the Engineering Department. The commercial design incorporated the production of anhydrous hydrogen chloride. During all the semicommercial operation, all the by-product hydrogen chloride was converted to muriatic acid since the small quantity available did not make commercialization of the anhydrous gas possible. Although Diamond had previous experience with anhydrous hydrogen chloride, no specific experience was available for this particular by-product gas. Thus, a modest technical and sizable financial gamble was made in installing equipment and pipeline facilities necessary to distribute the gas to customers.

Full-scale commercial operation began in early 1953. The quality of perchloroethylene was good, and generally satisfactory operation was experienced initially. However, within a few months after delivery of hydrogen chloride was begun, the company's largest customer for the gas encountered difficulties which seemed to be associated with the use of the hydrogen chloride. An intensive three- to four-month effort led to identification of a troublesome trace impurity and to a relatively simple but effective means for its removal. Highly satisfactory use of the hydrogen chloride has prevailed since that time. Furthermore, use of the hydrogen chloride has been subsequently extended to several other processes.

Manpower and Cost Requirements

Shown in Figure 1 and Figure 2, respectively, are the research and development manpower requirements for the entire development and the distribution of costs throughout the development period. These show the research and development requirements of the early commercial period. Special effort by the operating group is not included in these figures since it involved no major additions to the normal operating staff.

Personnel requirements rose sharply from a low of four to five people during the exploratory period to a peak of twelve to thirteen at the height of the pilot period. A steady decline followed, although a resurgence in manpower requirements occurred during the commercial period. This was a result of the special anhydrous hydrogen chloride problem and, to a moderate extent, to considerable field testing of perchloroethylene. Rates of expenditure were low at the start of the project because activity was limited to laboratory and desk work. Costs rose rapidly during the pilot period because of increased personnel. Although personnel requirements dropped, costs continued to rise rapidly during the semicommercial period because of larger scale material and equipment expenditures. A sharp rise in costs in the commercial period was again, of course, related to the anhydrous hydrogen chloride problem.

Approximate distribution of the work of the research group and of the development group into their principal activities is given in Table 1. One should note the large portion of the research activities required for the stabilizer development and field testing. The added effort, to a certain extent unanticipated, contributed heavily to the final success of the project.

Acknowledgment

Sincere appreciation is expressed herewith to all those in Diamond Alkali who provided help and suggestions, in particular, R. L. Annis, C. C. Brumbaugh, and D. J. Porter.

Presented at A.I.Ch.E. annual meeting, Chicago, Illinois.

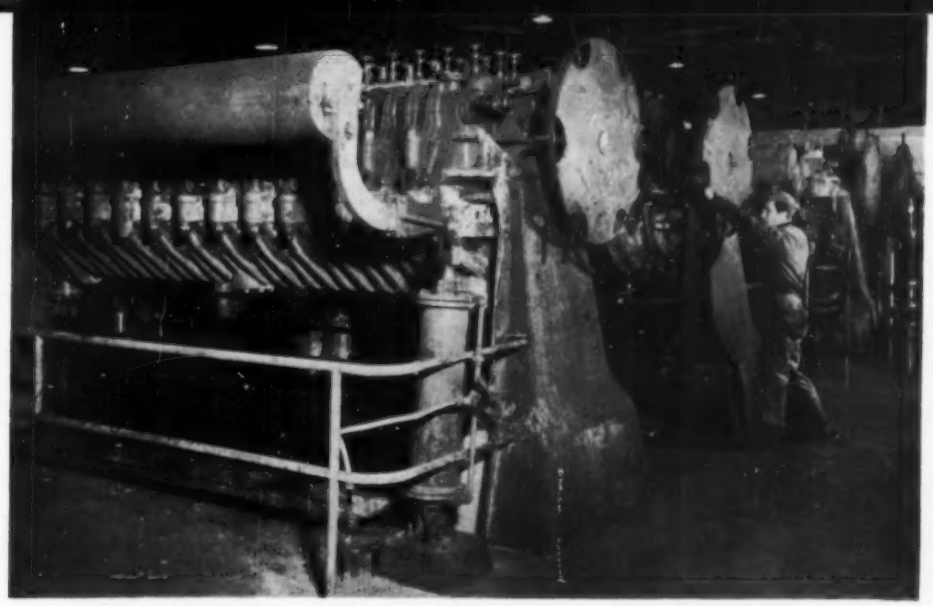
Comment

In terms of over-all results, the development is considered successful, especially when it is recognized that the project was Diamond's first organic chemical venture.

The time of development and the manpower effort are high when compared only in terms of the process and product accomplishments. In retrospect, it appears that some time and effort could have been saved. This might have been done in two ways: (1) by departing from the policy of bringing only the best material into the market, field evaluation of the perchloroethylene could have been started at an earlier date. As much as one-half to one-year reduction of time, with corresponding financial saving, might have been realized and (2) by closer examination of the hydrogen chloride gas during the semicommercial period, some but not all of the later problems could have been avoided.

As a result of the development, a broad background and a wealth of technical information were gained by the company. These were important to Diamond in its subsequent expansion in the field of chlorinated organics.

The specific process accomplishments have proved to be of considerable value to the company. The process for making perchloroethylene and, separately, the process for making ethylene dichloride, have been licensed to others. As a result of demand for its product, Diamond has again increased its facilities for manufacturing perchloroethylene. The commercial operation is being conducted with what are essentially the cheapest raw materials. Raw material efficiencies approach the theoretical. Hydrogen chloride is being completely recovered and is being sold for several different uses.



Sweetland pressure filters for filtering copper sulfides and strip residue (refinery installation).

simultaneous DISTILLATION OF AMMONIA and SEPARATION OF COPPER from nickel-bearing solutions

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In the accompanying article are reviewed the various stages in the development of a process for the simultaneous distillation of ammonia and the separation of copper from nickel, starting from laboratory work to pilot plant, and eventually to the design and operation of the commercial units.

In the production of refined nickel from nickel-copper sulfide concentrate, a pressure leaching and reduction process is employed by Sherritt Gordon Mines Limited, at Fort Saskatchewan, Alberta (*1*). During the development of this process (*2, 3*) it became apparent that an efficient method of separating the copper was necessary before the nickel in solution could be precipitated as refined metal. A systematic program was, therefore, initiated for the development of a process for separating the copper and nickel from leach solution.

Laboratory Study

During a systematic laboratory and pilot plant study (*5*), it was shown that if the leaching operation was conducted in two countercurrent stages a leach solution was produced which contained in addition to metal ions, thiosulfate and polythionate ions. By proper control of the leaching conditions the concentration of the thiosulfate and thionates could be varied (*4*). It was also shown that, upon distillation of the excess ammonia required for leaching, the unsaturated sulfur compounds reacted selectively with copper to form insoluble sulfides (*7*). In practice, it is difficult to remove copper completely during distillation, and hence small amounts of copper left in solution are stripped by means of such stripping agents as hydrogen sulfide (*8*). The laboratory work, consequently, involved the following four problems: distillation of excess ammonia, calculation for the number of theoretical steps required for the distillation, precipitation of copper as copper sulfides, and stripping of copper with hydrogen sulfide.

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1. DISTILLATION OF AMMONIA

The solution produced in the countercurrent leach operation is termed "adjustment leach solution" and has the approximate composition shown in Table 1.

Free ammonia is defined as the ammonia determined by titration with sulfuric acid. It is present in the adjustment leach solution in excess of the requirements for both the precipitation of copper sulfides and the subsequent nickel reduction. In order to boil out this excess free ammonia and simultaneously produce aqua ammonia of high concentration (170-220 g./

Table 1.—Analysis of Adjustment Leach Solution

Ni	40-50 g./liter
Co	0.7-1.0
Cu	5-10
$(NH_4)_2SO_4$	120-180
$NH_4SO_3 \cdot NH_3$	80-110
$S(S_2O_3^{=} + S_4O_6^{=})$	5-10
$NH_{3(f)}$(free ammonia)	85-100

Table 2.—Solution and Vapor Composition of Leach Solutions

Solution compositions (g./liter)							
Ni*	Co	Cu	$(NH_4)_2SO_4$	$NH_4SO_3 \cdot NH_3$	free NH_3	Mole fraction Liquid	Ammonia Vapor
47.8	0.9	0	173	107	34.5	0.0413	0.037
43.8	0.8	3.35	158	98	50.4	0.0605	0.138
43.0	0.8	5.60	155	96	60.8	0.0730	0.241
42.5	0.9	5.85	154	94	65.7	0.0786	0.280
44.0	0.8	5.90	159	98	76.6	0.0920	0.330
40.9	0.9	6.10	152	94	76.4	0.0916	0.369
41.0	0.9	6.30	152	94	83.5	0.1000	0.438

* Ni, Cu, and Co are in the form of $[Me(NH_3)_x]SO_4$ complexes.

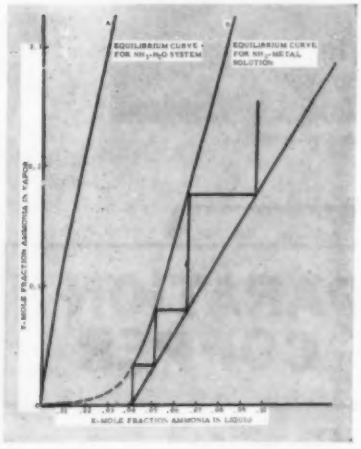
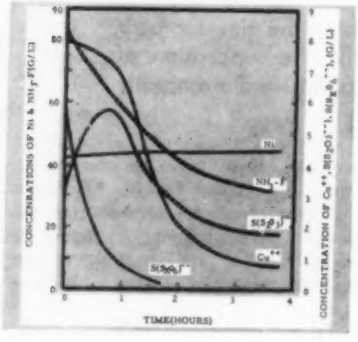


Fig. 1. Graphical calculation for theoretical plates required for distillation.

Fig. 2. Change in concentration of various components during boiling (5).



liter) for recycling to the leach circuit, a distillation step is required. For calculating the number of plates required in the still, data on vapor-liquid equilibrium are needed. Although such data are readily available for pure aqua ammonia solutions, they are not valid when the solution contains ammonium salts and metallic ions which form complex ammines.

Accordingly, the vapor-liquid equilibrium relationship of the solution was established experimentally by using a standard dynamic method (*6*) of measuring the vapor pressure of solutions. A set of data obtained for the compositions of solution and vapor is listed in Table 2.

2. CALCULATIONS FOR NUMBER OF THEORETICAL PLATES

The vapor-liquid composition diagram, as determined empirically, was used to calculate the number of theoretical plates required. It is apparent that, for a general solution to the problem, a component in solution, so defined that any effect from other constituents, e.g., complexing ions, is properly accounted for in the equilibrium relationship, should be used. In this particular case, however, the function free ammonia was selected as the component in solution, since it was possible to maintain the concentration of metallic and ammonium ions during the laboratory and pilot runs more or less the same as anticipated in the commercial unit. Hence the need for evaluating a general ammonia function was conveniently eliminated.

As shown in Figure 1, line *OB* is the vapor-liquid equilibrium line for ammoniacal solutions containing 41-48 g./liter Ni, 0-7 g./liter Cu, and 150-180 g./liter $(NH_4)_2SO_4$. Line *OA* is the equilibrium line for pure ammonia-water solutions. Line *OB* starts flat, then rises sharply and runs approximately parallel to line *OA*. This deflection point corresponds to a molar ammonia to nickel ratio of approximately 2.0/1, indicating that the nickel diammine is a relatively stable complex even at normal boiling temperatures. This has been verified in a number of boiling tests in nickel diammine solutions. The area between the two lines indicates the depressing effect of the complexing ions and ammonium salts on the vapor pressure of the solution.

A number of additional modifications and assumptions was made before the standard McCabe and Thiele method was used. The concentration of solution in the reboiler would increase during boiling, resulting in crystallization of nickel salts, unless water was constantly added to the reboiler. The equation of the operating line must be modified accordingly. The precipitation of copper sulfides and the corresponding neutralization of ammonia were assumed to occur in the reboiler, though in actual practice some sulfides would precipitate about two plates above the reboiler. Further-

Table 3.—Chemical Conditions During Pilot Run
(April 20-26, 1953)

Flow stream	Mean analysis (g./liter for solution, % for solids) Ni	Co	Cu	$S_{(t)}$	$S(SO_4)$	$S(S_2O_3)$	$S(S_4O_6)$	$NH_{3(t)}$	$NH_{3(f)}$	NH_3
Adj. leach solution	42.9	0.56	5.1	78.1	54.9	3.4	1.9	134	96.1	9.11
Dilution feed soln.	0.31	0.01	....	7.35	5.67	0.30	0.53	10.3	2.82	0.47
Boil condensate	....	....	....	.....	.....	...	....	....	240	
Copper sulfide residue	0.46	0.02	73.14	22.23						
Boil filtrate	46.66	0.60	0.55	84.7	63.2	1.8	0.6	80.2	34.0	10.8
Strip residue	12.17	1.01	34.3	28.0						
Copper free soln.	45.6	0.59	0.005	82.6	62.0	1.65	0.18	78.3	32.8	10.5

more, since the heats of vaporization of the vapors varied within 3% between the top and the bottom plates, molar latent heats were assumed constant throughout the system.

The number of theoretical plates required was found to be 2.5 plates above the reboiler.

3. PRECIPITATION OF COPPER AS COPPER SULFIDES

Upon boiling the solution to decrease the free ammonia content, the unsaturated sulfur ions (thiosulfate and thionates) are decomposed and copper sulfides are precipitated. During preliminary experiments on the study of the reaction between thiosulfate and copper, the following results were obtained:

(a) The reaction was approximately first order at temperatures above 200° F.

(b) The activation energy of the reaction when using 1 mole thiosulfate per mole of copper was 16 k. cal.

(c) An increase in ammonia concentration lowered the rate of precipitation; in a particular example the time required to reach a given copper concentration was doubled for an addition of 5 g./liter free ammonia.

In Figure 2 the change in concentration of free ammonia, copper, thiosulfate, and polythionates is shown graphically during a boiling operation (5). It can be seen that as the ammonia concentration decreases, the polythionates decompose rapidly and copper is precipitated by decomposition of both thiosulfate ($S_2O_3^=$) and polythionates ($S_xO_6^=$). After three hours the rate of precipitation of copper becomes uneconomically slow. The following equations are written to represent the mechanism of precipitation:

$$S_3O_6^= + Cu^{++} + 2H_2O \rightarrow 2SO_4^= + CuS + 4H^+ \quad (1)$$

$$S_2O_3^= + Cu^{++} + H_2O \rightarrow SO_4^= + CuS + 2H^+ \quad (2)$$

$$8Cu^{++} + 2S_2O_3^= + 4H_2O \rightarrow 8Cu^+ + S_3O_6^= + SO_4^= + 8H^+ \quad (3)$$

$$2Cu^+ + S_3O_6^= + 2H_2O \rightarrow Cu_2S + 2SO_4^= + 4H^+ \quad (4)$$

According to the above equations both cuprous and cupric sulfides should be formed. The composition of the copper sulfide precipitate indicates that such a mixture is present.

For efficient precipitation of the sulfides, it has been found experimentally that the ratio of unsaturated sulfur [as $S(S_2O_3^=)$ and $S(S_xO_6^=)$] to copper in solution should lie between 0.8 and 1.2. The precipitation commences when the free ammonia concentration falls below 70 g./liter. The boiling operation is controlled so that the molar ratio of free ammonia to nickel in the discharge solution drops to between 2.3-2.4 for the subsequent reduction operation.

4. STRIPPING OF RESIDUAL COPPER IN SOLUTION WITH HYDROGEN SULFIDE

After the distillation of ammonia and the precipitation of copper sulfide, there is usually from 0.1 to 0.5 g./liter

Fig. 3. Schematic flow diagram of copper removal circuit (pilot scale).

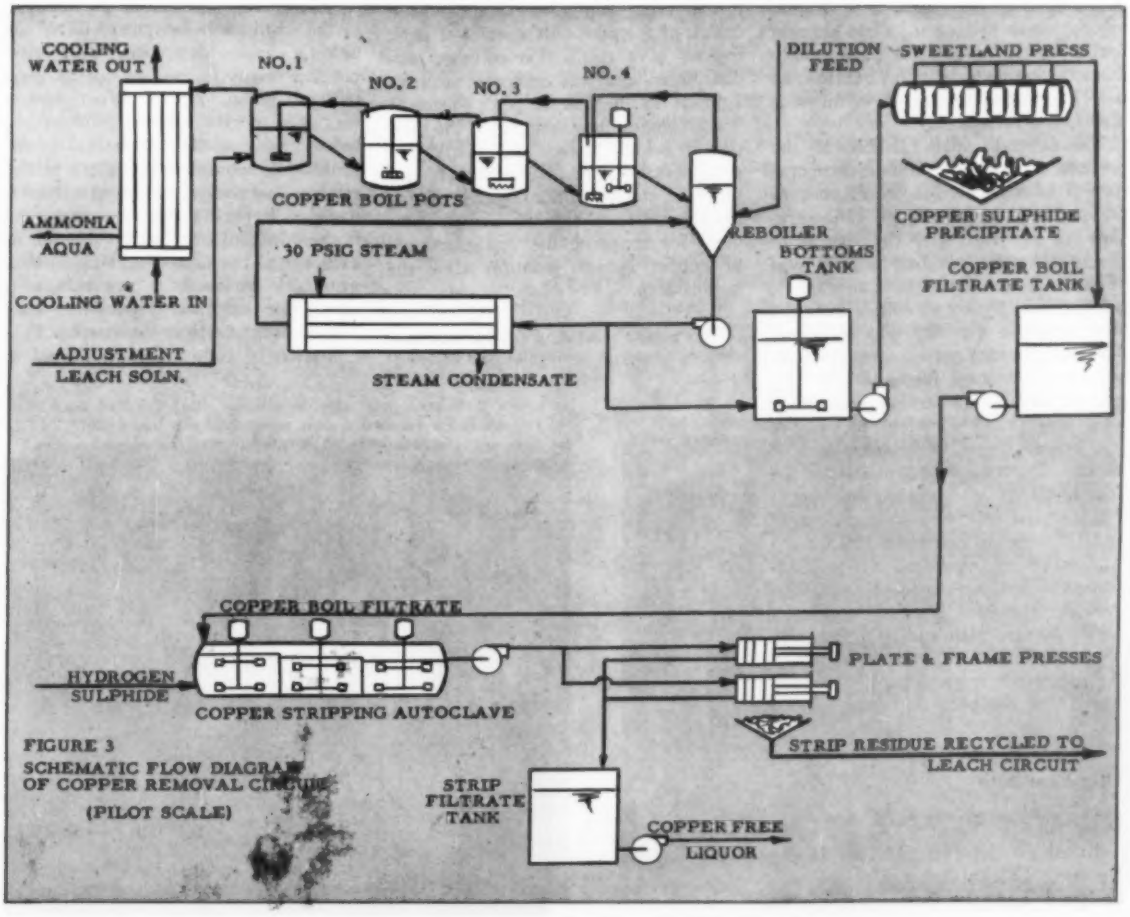


FIGURE 3
SCHEMATIC FLOW DIAGRAM OF COPPER REMOVAL CIRCUIT
(PILOT SCALE)

Table 4.—Operating Conditions During Pilot Run

A. *Copper boil unit*			
Feed solution		Flow	0.54 Imp. gal./min.
		Temperature	78° F.
Temperatures		First pot	196° F.
		Second pot	209° F.
		Third pot	211° F.
		Fourth pot	213° F.
		Reboiler	219° F.
Boil dilution		Flow	0.09 Imp. gal./min.
		Temperature	78° F.
Reboiler discharge holding tank			214° F.
Ammonia condensate		Flow	0.145 Imp. gal./min.
Total vol. of feed solution processed			18,800 Imp. gal.
B. *Stripping unit*			
Temperature		Stripping autoclave	206° F.
Retention time			2 hr.

copper left in solution. Relying on the presence of thiosulfates and polythionates alone was found to be impractical, due not only to extremely long reaction time required to decrease the copper concentration but also to the difficulty in effecting complete removal. Artificial stripping reagents, therefore, must be injected into the solution to precipitate copper sulfide without precipitating nickel or cobalt. A number of reagents were tested, among which hydrogen sulfide gas was found to be satisfactory, especially from the commercial point of view, as described later. Flour of sulfur was also found satisfactory.

The effect of such variables as the amount of hydrogen sulfide, temperature of solution, free ammonia concentration, and initial copper concentration on the rate and the extent of precipitation of residual copper was studied. It was found that at 200° F., a 5% excess hydrogen sulfide over the stoichiometric quantity was sufficient. The reaction rate increased as the temperature increased from 180-200° F., and at 200° F. a retention time of 15 min. was found sufficient to remove the copper down to 0.02 g./liter or lower. The rate of reaction and the completeness of precipitation was found to be relatively independent of small changes in free ammonia concentration, and changes in initial concentration of copper from 0.5 up to 2.0 g./liter. However, good agitation was found necessary to ensure a fast rate of precipitation. Typical analysis of the precipitate is given later in the discussion of the pilot operation (Table 3).

Pilot Plant Data

1. DESCRIPTION OF THE PILOT UNIT

Based on the data obtained in the Research Laboratory, a pilot unit was designed and put into operation in March, 1953. Data obtained in the laboratory tests indicated that 2.5 theoretical plates above the reboiler were required. Assuming an over-all efficiency of 60%, a distillation unit with four plates plus the reboiler was considered for the pilot plant. With the copper precipitating simultaneously as the concentration of free ammonia was lowered in the boiling operation, scaling by the precipitate was anticipated in the boiling equipment. Hence in the design of the pilot unit a series of pots, instead of a distillation column, was considered and was equipped with an agitator in the lowest pot. Figure 3 is a schematic flow diagram of the pilot circuit which shows the distillation pots, bottoms tank for further precipitation of copper sulfide, filter press for the separation of sulfides, and an autoclave for stripping the small amounts of copper left in solution after the boiling step.

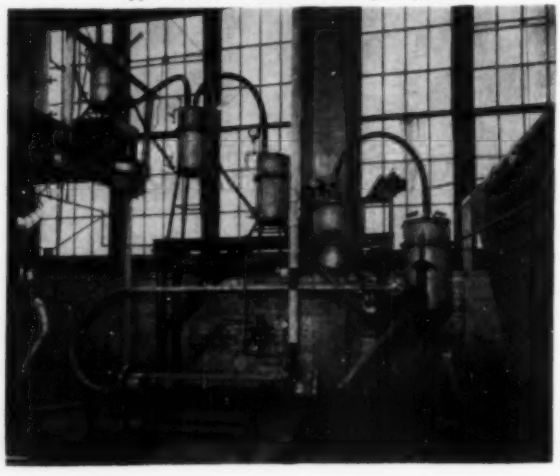
Four pots, a reboiler, a vertical tube-and-shell condenser, a horizontal tube-and-shell steam heater comprised the distillation equipment. Each boil pot was 16-in. I.D. × approx. 30 in. Solution outlets were located about 9 in. from the bottom and inlets about 2 in. from the bottom. Vapor outlets were located at the top of each pot; inlets were located below the liquid level and were either enlarged pipe openings with zig-zag edges or horizontal rings with slotted openings facing downwards. The reboiler was constructed similar to the pots, but was equipped with a conical bottom. The horizontal tube-and-shell steam heater for heating the solution from the reboiler consisted of twenty tubes, 0.84-in. O.D. and 0.62-in. I.D., and 6½ ft. long. Steam was fed to the shell side and solution to the tube side. The vertical tube-and-shell condenser for condensing the ammonia-water vapor from the first pot consisted of twenty-four tubes, 0.84-in. O.D. and 0.62-in. I.D., and 8 ft. long. Vapor was fed to the shell side, and cooling water to the tube side. All parts in contact with the leach solution were constructed of Type 316 stainless steel. Tubes in the condenser were mild steel.

The filter press used for filtering the copper sulfide was a small-scale Sweetland press. A horizontal autoclave 2-ft. diam. × 7 ft. and having three compartments was used for stripping the copper. Two plate-and-frame presses were used for filtering the strip residue.

2. OPERATING CONDITIONS

In the pilot operation the adjusted leach solution was fed to the top pot of the distillation equipment. The solution cascaded down each successive pot and finally to the reboiler. A centrifugal pump, 2CG-1 Worthington, was used to circulate the solution between the reboiler and the steam heater. Evaporation took place in the reboiler and the vapor was transferred upwards to each pot in succession. As it came in contact with the solution in each pot at the slotted opening, it was gradually enriched in ammonia content. The enriched vapor was condensed in the vertical condensers. Precipitation of copper sulfide started in

Copper boil unit installed in the pilot plant.



the third pot but the bulk of it was precipitated in the reboiler where the free ammonia content was properly controlled. The solution and copper sulfide slurry were withdrawn from the reboiler and transferred to the bottoms tank where additional retention time further precipitated the sulfide. In order to maintain proper metal concentration in the reboiler, dilution liquor was added to the reboiler. This liquor was usually wash water from the filtration of the leach residues and copper sulfides.

The sulfide slurry was fed to the Sweetland filter press to separate the copper sulfide. The filtrate then was pumped to the horizontal autoclave where further precipitation of copper sulfide was accomplished by selective interaction with hydrogen sulfide gas. The residue was separated in the plate-and-frame press, and being contaminated with nickel sulfide was recycled to the leaching circuit. The filtrate was now sufficiently low in copper content for the subsequent nickel-reduction operation.

For pilot operation a solution flow rate of ½ Imp.gal./min. was used. Chemical conditions existing at various points in the circuit are tabulated in Table 3; other operating conditions are given in Table 4.

3. RESULTS OF PILOT PLANT

a. *Efficiency of Distillation*

As shown in Table 3, the vapor from the top pot was sufficiently enriched in ammonia to produce a 20% aqua ammonia. Hence the pilot run proved that four pots and a reboiler were ample to produce aqua of required concentration. The same scheme was, therefore, adopted in the design of the commercial size equipment.

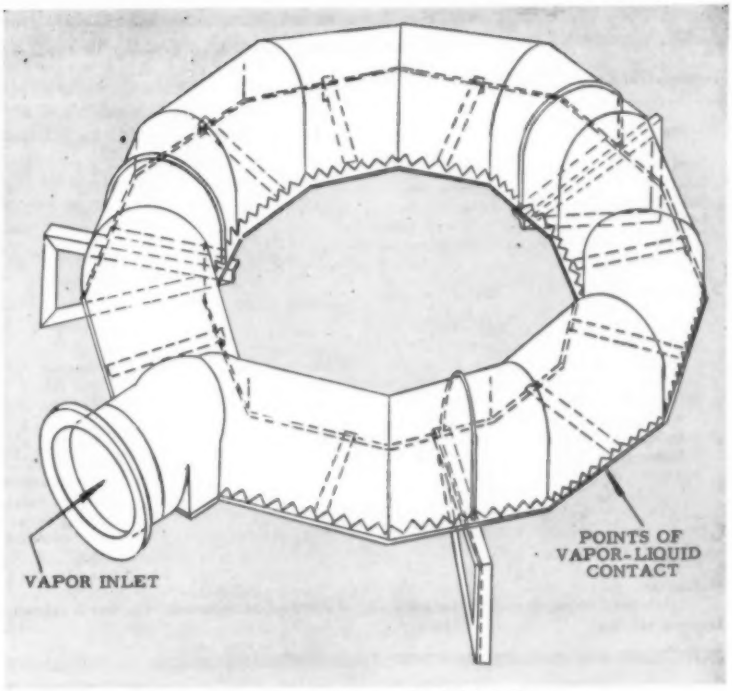


Fig. 4. Detail of vapor injection ring inside boil pots.

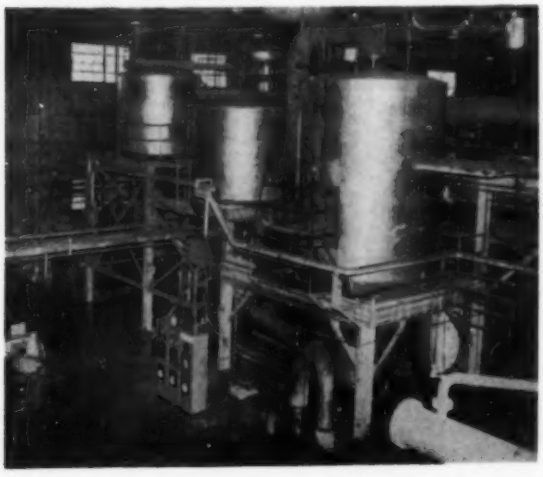
b. *Efficiency of Copper Sulfide Precipitation*

At the start of the pilot run a retention time of 20 min. was allowed in the bottoms tank. Under this condition only about half the total copper in solution precipitated, giving rise to high recycle of copper from the strip residue. By increasing the retention time at the bottoms tank, by about 100%, it was possible to increase the amount of copper precipitated, up to 90%. This increased retention time was, accordingly, incorporated in the design of the full-scale equipment.

c. *Scaling in the Distillation Equipment*

The pilot runs revealed that the scaling of copper sulfide was severe in the pots, the reboiler, and especially in the steam heat exchanger. The tubes required frequent drilling with mechanical tube cleaners. Anticipating this scaling difficulty to be multiplied in commercial operation, an alternate method of operation was worked out whereby instead of using the steam heater, steam was injected directly to the reboiler, not only to supply heat, but also to keep the solution properly

Copper boil unit, with reboiler in right foreground, and four pots above and counterclockwise from it (refinery installation).



Copper stripping autoclaves (refinery installation).

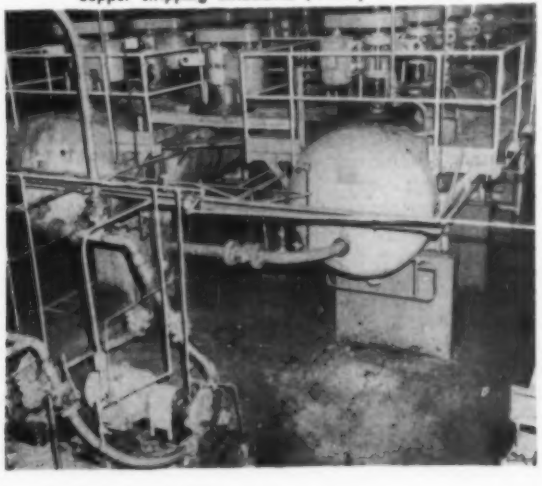


Table 5.—Operating Conditions Existing in Present Commercial Unit

1. *Analytical data* (g./liter for solution, % for solids)

Material	Ni	Ni + Co	Co	Cu	Total	Sulfur SO_4	Sulfur S_2O_3	Sulfur S_4O_6	Bromate * Total	NH_3 Free	NH_4
Feed solution		44.9		6.8	107		1.5	6.8	149	82	
Boil filtrate		44.4	0.7	0.2	110				5.4 108	30	
Strip filtrate		44.3	0.7	0.01	110	94			109	30	12.4
Boil condensate									202		
Copper sulfide	1.04		0.1	66.1							
Strip residue	9.2		1.1	22.2	23.3						

2. *Physical data*

			T ° F.	lb./sq.in. gauge
Solution feed rate	136 Imp. gal./min.	Preheated Feed Solution	181	
Copper sulfide production	11 tons/day	Pot No. 1	194	1.8
$(NH_4)_2SO_4$ recycle	116 tons/day	Pot No. 2	211	2.2
H_2SO_4 consumption	26 tons/day	Pot No. 3	219	3.8
Sulfur consumption	0.17 tons/day	Pot No. 4	223	4.7
Steam flow	12,000 lb./hr.	Reboiler	229	5.1
		Boil condensate	94	
		Cooling water in	59	35
		Cooling water out	89	
		Strip autoclaves	217	
		H_2SO_4		32
		Steam		33

* Arbitrary value, depending on normality of standard bromate solution, that is, above value is based on using 5-ml. sample and 0.008 N bromate solution.

diluted. As will be discussed later, this alternate method was found to be more practical in the commercial operation.

d. *Stripping*

Hydrogen sulfide was found to strip copper from solution, reducing the copper concentration in solution to below 0.005 g./liter. Hence this method was adopted for the full-scale operation.

Commercial Unit

DESIGN *

From the pilot run which lasted close to two months it was possible to assemble data of sufficient accuracy to proceed with the final design of the full-scale commercial equipment. Apart from the difference in size the commercial unit was similar to the pilot unit, with only few minor modifications.

As in the pilot unit, four pots and a reboiler were the main pieces of equipment for the copper boil step. In each pot, vapor injector rings were installed to get efficient contact between vapor from the lower pot and the solution inside the pot. Figure 4 shows the detail of one of these injector rings. Agitators were installed on the third and fourth pots. An entrainment separator was installed in the vapor line between the first pot and the condenser to prevent entrained solution from getting into the condenser. A series of pots was used instead of a single distillation column since the pilot runs had proven that severe scaling of copper sulfide would be encountered. Two horizontal stripping autoclaves were installed, each with five compartments. In all, four Sweetland presses were installed, two each for the filtration of copper sulfide and strip residue.

All pieces of equipment in contact with metal bearing solution were constructed of type 316 stainless steel (e.l.c.).† The vapor condenser in the copper boil section was constructed of carbon steel, but with stainless steel tubes. The selection of these materials was based on results from a number of corrosion tests conducted during the pilot operation.

OPERATION

The commercial unit was brought on stream early in the summer of 1954 following the start-up of the leaching circuit. It was operated with reasonable success for some time before its shortcomings developed and could be rationalized.

Heat was introduced to the original circuit by pumping a large mass of sulfide slurry from the reboiler through the tubes of a horizontal shell-and-tube heat exchanger and back to the reboiler. Steam on the shell side provided the necessary heat, and control was maintained by throttling the condensate. Two sets of pumps and heat exchangers were provided because of the known fouling of the tubes with sulfide. However, the task of cleaning these heat exchangers attained such proportions that better methods were sought from the beginning.

Provision had been made to introduce live steam to the liquid phase of the reboiler, and this was developed to the point where the heat exchanger could be eliminated. Since considerable dilution was unavoidable, some relief was gained by preheating the sulfide-free solution in a standard jacketed-pipe installation. Some efficiency in distillation was sacrificed, but that was tolerable when one considers the higher efficiency of the unit than had been anticipated.

The horizontal shell-and-tube vapor condenser was also found to be difficult to operate. The vertical condenser, for condensing the enriched ammonia-water vapors, was found to operate satisfactorily. The entrainment separator, installed between the first pot and the condenser, worked well in removing solution entrained in the vapor.

The bottoms tank, which was understood to be beneficial in promoting a continuance of the precipitation reaction, was repeated in two additional agitated tanks in series ahead of the filter feed pumps. This had the added advantage of permitting closer control of the ammonia concentration separate from the need to promote precipitation.

Other modifications followed as the need arose. The recycle of ammonium sulfate which was necessary to maintain the proper nickel complex for subsequent reduction was reduced in part by the direct addition of sulfuric acid to the reboiler. By fixing ammonia, this addition also permitted control of the sulfate production. The heat generated was an added benefit, and relieved the steam demand.

The stripping reaction was assisted by the addition of flour of sulfur to the re-

* Designed by Chemical Construction (Inter American) Ltd., based on pilot plant data.

† (extra low carbon)

boiler, permitting greater variance in the polythionate : copper ratio. This has since been supplemented by the recycle of strip residue which provides its own stripping agent in the form of nickel sulfide. (See Figure 5).

Although considerable work has been done and is continuing to be done to gain greater flexibility of control, the prime control function still lies in proper control of unsaturated sulfur to copper ratio in the adjustment leach step, just ahead of the copper boil step. This step, as the name implies, is controlled to adjust the solution with respect to concentrations of copper and unsaturated sulfur compounds. Precipitation has been found to proceed best with a 1 : 1 g./liter ratio of S (as thiosulfate and thionate) to copper. With lower ratios, insufficient sulfur is present to cause the reaction to proceed towards completion, and at higher ratios too much sulfur is left in this unoxidized state for subsequent circuits to handle.

There are two controlled functions: the copper concentration, which indicates the efficiency of precipitation, and the NH_3 : Ni mole ratio, which indicates the degree of distillation related to the nickel concentration. This ratio should be just over 2 in the nickel reduction operation, and since two high temperature operations intervene where some free ammonia is evaporated, it is controlled at about 2.3 in the reboiler. The copper concentration should be as low as possible, consistent with low nickel content in the copper sulfide.

At present, solution feed rate, acid flow, steam flow, and reboiler slurry level are all automatically controlled. Cooling water to the condenser is also controlled, resulting in a circuit which can be operated smoothly.

Operating conditions, both physical and chemical, of the commercial unit are tabulated in Table 5.

Acknowledgment

The authors wish to express their appreciation to Sherritt Gordon Mines Limited, and especially to E. L. Brown, president, for the opportunity to work on the process described in this paper, and the permission to publish the data. The assistance received from various members of the staffs of the Chemical Metallurgical and the Research and Development Divisions of the company is gratefully acknowledged.

In addition, the authors wish to mention their indebtedness to the late S. Nashner, formerly manager of the Chemical Metallurgical Division, for his many contributions to the development of this process.

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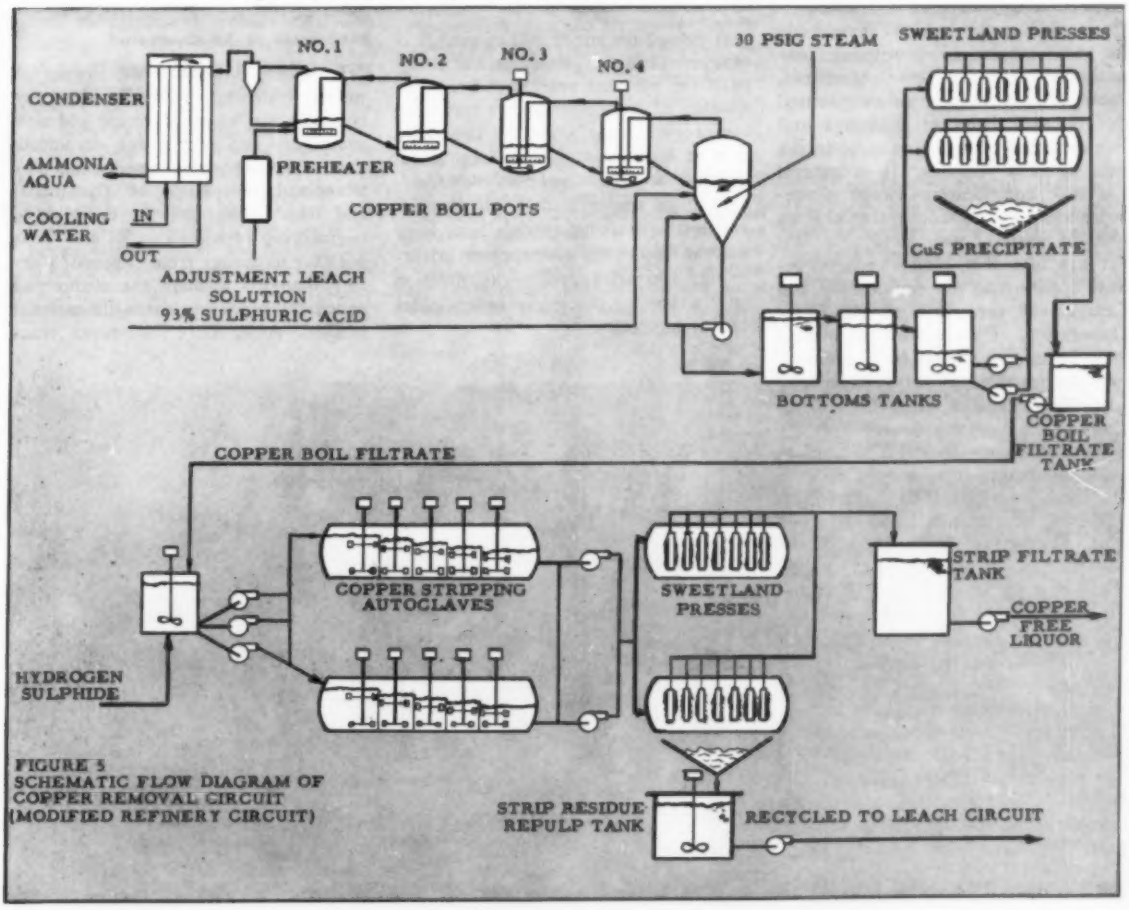
Presented at A.I.Ch.E. annual meeting, Chicago, Illinois.

Fig. 5. Schematic flow diagram of copper removal circuit (modified refinery circuit).



use of MODELS

in design and construction

Arthur E. Michel *

The Fluor Corporation Ltd.
Los Angeles, California

When properly used by engineers, scale models will save money in design and operating costs. In the accompanying article author Michel predicts a time in the not-too-distant future when everyone will look upon a model as being as much a part of the job as specifications and drawings.

Engineers and scientists have made great strides in developing new machines and products. Machines, however, have become so complicated that it takes bales of drawings and thousands of man-hours to make design ideas become realities. It is natural that such complications breed misunderstanding and misconception plus an inherent waste of manpower.

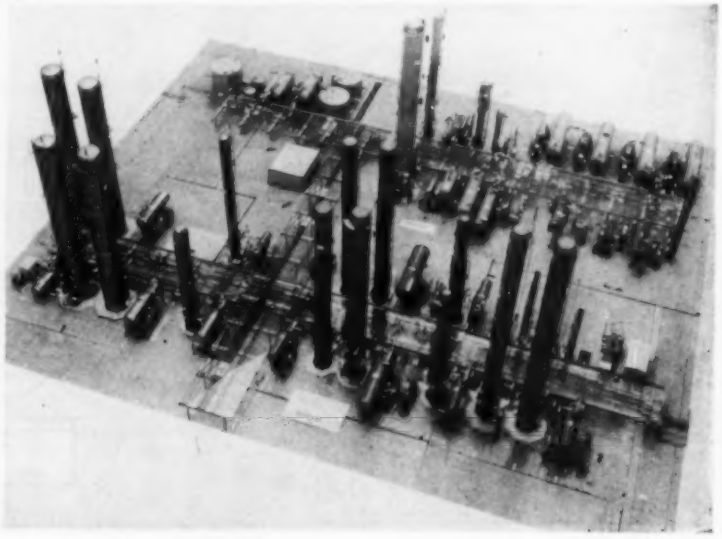
Years ago this ineffectiveness became apparent to the engineering and management personnel of the Fluor Corporation. Convinced that models could be effective tools in eliminating poor design, this corporation wholeheartedly undertook a model-making program, pioneering many of its model-making methods but not, however, pioneering the *use* of models. For years the shipbuilding, automotive, and the aircraft industries had been using models to express design ideas. The chemical and petrochemical industries had made attempts at their use, but they usually made the mistake of making a model after the drawings were made. This was unsatisfactory and bordered on being worthless. Fluor strived to have a model built as rapidly as the design ideas unfolded so that these ideas could be quickly and easily examined, improved upon, and eventually dovetailed into a workable, efficient plant. This spelled achievement.

Although the entire cost of models is charged against drafting, drafting costs for the past year have been one quarter of a million dollars less than the previous year while the same volume of business has been maintained. Much of this decreased cost is attributable to the use of models. Besides the savings in drafting, models have been a great help to the construction, advertising, and sales groups—to mention only a few of the many beneficiaries of this method.

Hindrances to be Conquered

In order to achieve the degree of success which has been effected, many obstacles had to be overcome and new techniques and procedures developed. One of the important impediments was to obtain acceptance of the model and then to instruct the design and engineering personnel in its use. It is not easy to change from expressing design thoughts through the medium of pencil and paper to a three-dimensional method. After more than seven years

Fig. 3.



* A. E. Michel is principal designer.

of operation with models, the following procedure was put into effect. This really works and has gained wide recognition.

Before itemizing the procedure, right here it must be thoroughly understood that models only *help* one to see a problem more clearly; they are not a cure-all. It is not even always wise to make a model. Judgment gained through experience determines whether to make a model and what scale and detail to employ. There is no hard and fast pattern to fit all conditions. The route most generally followed by Fluor is:

Topographical Model

Where the plant site terrain is such that cut and fill is a fair-sized problem, a small-scale (often 1 in. = 50 ft.) topographical model is built. Figure 1 shows a typical model which was made of one of Fluor's plants. This model aids in determining the most ideal location of equipment, roads, etc., often making the hilly topography work to an advantage. With it, general over-all plant arrangement is established.

The model is made with a wooden frame, rough graded with a plywood cover. Over this cover is stretched chicken wire for reinforcing. Casting plaster of a medium hardness is mixed and plastered on. After this is set up, accurate contours are formed in the casting plaster with cutting tools. Coats of sealer and paint are then applied.

Now the designer begins his study to determine the most ideal location of equipment and roads. The model makers supply the designers with the small-scale replicas of the major equipment and buildings. The designer establishes what he conceives to be the ideal arrangement. He then calls in the process engineer, project engineer, and construction engineer for consultation. Through their combined suggestions an agreement is reached on the general plant arrangement. At this point the customers' engineer is called in to give his approval of this over-all plant layout.

General Plot Plan Drawing

A drawing is then made of the plant from the model which is located at the elbow of the draftsman.

EQUIPMENT ARRANGEMENT MODEL

An equipment arrangement model of each unit is next developed. The plant shown in Figure 2 is the process area of a complete refinery which was recently contracted to design and construct. The designers are busily engaged in shifting equipment around trying to devise a layout which embodies as many ideal design conditions as possible. It was found that a $\frac{3}{8}$ in. = 1 ft. scale is generally the best to use. It is the same scale which is used on most of the piping drawings. Everyone becomes accustomed to visualizing clearances uniformly with the help of this same scale. Equipment such as pumps, turbines, exchangers, vessel components have been prefabricated and stockpiled. Special equipment is made within minutes by highly skilled and well-equipped model makers. They are working in close proximity to the designer so that communications are as short as possible—an important consideration when one is establishing the location of a model shop. Fluor actually has model-making equipment and drafting tables for layout designers located in the same room. Model tables, with grid lines on 5-ft. increments, are used for this equipment layout model. Unit boundaries are laid out on these tables with narrow, preprinted, scotch-type tapes. The equipment of a particular unit or process is painted with an identifying color. The designer is now faced with locating the equipment, buildings, pipe supports, etc. This he does by following the same mental processes that he used when he was "laying out" with cutouts or directly on paper. The big difference here is that he is getting the third dimension into the picture. This is a great aid to him.

When he has arrived at a plan satisfactory to him, he again calls a meeting of all the people who are responsible for the project and who can contribute to the improvement of the layout. This first arrangement and subsequent arrangements are photographed so that they may be studied further to determine which has the most ideal conditions. Pictures of this model are quite often sent to the customers' home office to be used as a progress picture and sometimes for advertising purposes.

UNIT PLOT PLAN DRAWING

After the equipment arrangement has been approved by both company and customer, a plot plan drawing is made by a draftsman. This includes coordinates tentatively locating the equipment.

Fig. 1.

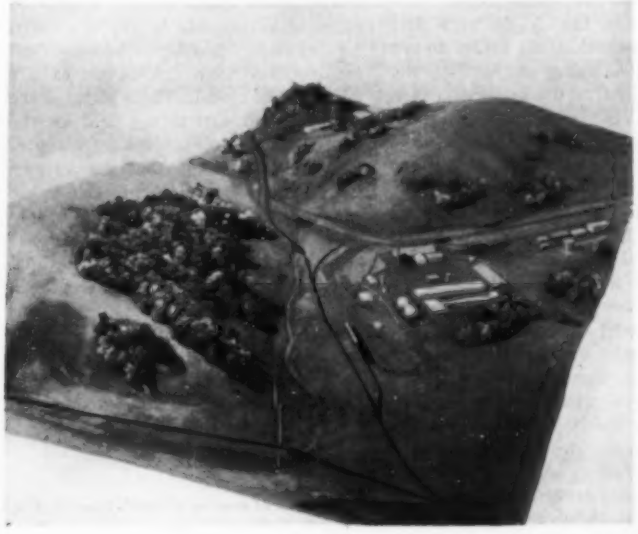


Fig. 2.

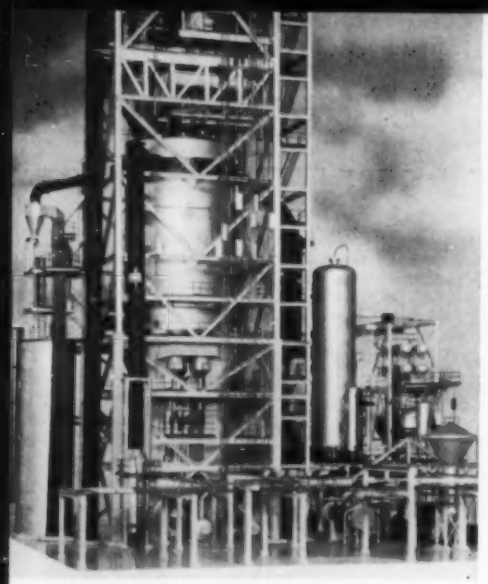
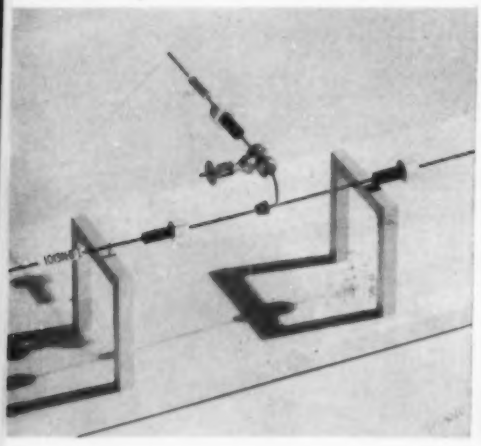


Fig. 5.

Piping Layout Model

In Figure 3 is shown a piping layout model of a refinery unit which the corporation recently designed. Much of the equipment, made for the "Equipment Arrangement Model," is used for this model. This is the most complex and most important phase of design models. The piping designer, working with the model maker, determines where the plot should be broken up into convenient-sized model boards. These boards are then made and the equipment is mounted on the boards. While the model maker is doing his work, the designer is making some rough studies on paper of the piping layout and also orienting the vessel nozzles so that the vessel drawings can be issued for fabrication. The piping designer now starts routing the pipe lines on the model, beginning with large, important lines. A choice is given to him on how to go about this —either he installs the line himself or he directs the model maker orally or with the use of sketches. This latitude is allowed because generally the designer is the best judge of which is the most effective and efficient manner. However, the company advocates that the wire bending be left to the model makers as far as practical and that the piping designer utilize his time in figuring the best routing for the lines.

Fig. 4.



All pipe lines with 1/16-in. diam. penetrated brass wire are indicated. The actual diameter of the pipe line is shown in Figure 4 with a split black rubber sleeve and insulation is shown with a larger white rubber sleeve. Much time and money have been spent in experimenting to find the ideal material for showing pipe lines. Experiments with solid plastic indicated it was too time-consuming to install and too hard to change. Full scale, slip-on-type sleeves and fittings were tried. This method had some advantages but due to the friction type of joint these lines were constantly being jarred out of place.

The following advantages were found in the use of half-hard penetrated brass wire:

- It could be bent into configurations easily with a long-nosed plier.
- Rigid branch connections can be made quickly and easily with a soldering iron.
- Clearance consideration could be determined with rubber sleeves.
- It is rigid yet easily modified.
- Being black, it shows up well photographically.
- Being inexpensive, improvements in line routings are made without there being any misgiving about waste of material.
- When changes of line size are requested many times, this means changing only the snap-on tags and the rubber sleeves without removing the line from the model.
- No special tools or skills are required to put one of these lines on the model.

This is the method Fluor adopted and is currently using.

As the lines are installed on the model, the supervisors and engineers are watching this development. Improvement can readily be seen and changes requested. This ability to see rapidly what is being proposed by the designer is one of the biggest advantages of models. It is almost like touring a full-scale plant. It is always easy to walk into a plant after it is completed and see many places where it could be improved, hindsight being always so much better than foresight. Normally, all process lines, utility headers, and all utility lines which incorporate a control valve are shown on the layout model (Figure 5). Included also are such instrument items as gauge glasses, liquid level controllers, orifice flanges, and instrument lines rack. While the model maker is installing pipe, the designer is working out congested areas on sketches. Sometimes it becomes necessary to work out an extremely tight arrangement on layout paper to determine if it will all fit together.

All Groups Play Significant Roles

During this period of development of the model, other design groups such as electrical and instruments are viewing the model and making sketches to locate their equipment. Electric racks, switch gear, etc. are installed on the model as the information is developed. When all these lines and instruments are installed to the satisfaction of the designer, he again calls for a layout review by all principals and key men concerned with the project. The process engineer leads this review, taking each line through start-up and shutdown. He is watching for operational problems, location of operating valves, etc. A member of the flow sheet group checks off each line and valve as the review is made. The principal piping designer is watching for such things as economics of line routing, flexibility, operation clearances, general appearance, and safety. The construction engineer is concentrating on installation and maintenance problems. The project manager has the responsibility of looking at it from all angles and compromising the desires of the various specialists.

When all the lines, valves, instruments, and structures have been reviewed to the satisfaction of this group then this plant is off to the proper start designwise. After the changes from this conference have been incorporated into the model, then the customer's engineers are called in to review and approve the layouts. It has been gratifying to Fluor and to the customer to find that little change is necessary at this point and from here on out because a better design job is possible with the aid of this new tool.

The layout model sections are placed as close as possible to the draftsmen for his ease when he is making final construction drawings. Pictures are taken of the model. These pictures are enlarged and sent to the field for the construction forces. One can appreciate the advantage that the various craft foremen have in being able to see at a glance what they are going to build. At times the layout model has been brought up to date with the final construction drawings and has been shipped to the field for use in construction and for the customer's operator training. Sometimes a full-scale showpiece has been built for customer's use in public relations and operator training.

Presented at meeting of South Texas Section, A.I.Ch.E., Galveston, Texas.

HOW TO OBTAIN

greater throughput

IN SCRUBBING OPERATIONS

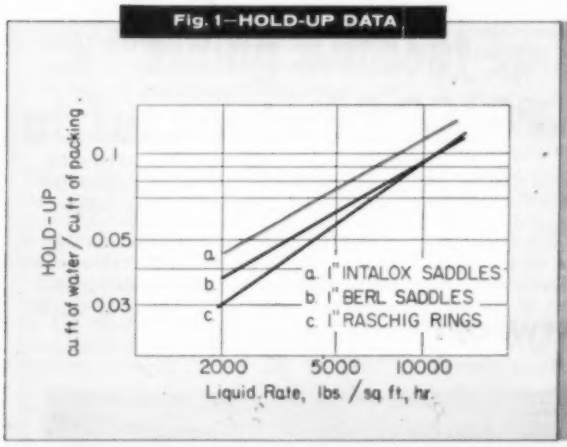
Greatest throughput in scrubbing operations is obtained at a balance point where maximum wetting of the packing occurs without flooding the tower. Maximum wetting involves a higher liquid hold-up.

Intalox saddles pack with greater randomness, form a loosely packed, yet tightly interlocked bed free from blocked areas, with higher surface area, and what is especially important, as far as throughput is concerned, provide a bed of greater and more uniform voidage.

As a result it is possible with Intalox saddles to have a higher liquid hold-up than with other packings yet still retain the low pressure drop characteristics of Intalox since the higher liquid hold-up results from a greater wetted-surface-area rather than from liquid-filled voids.

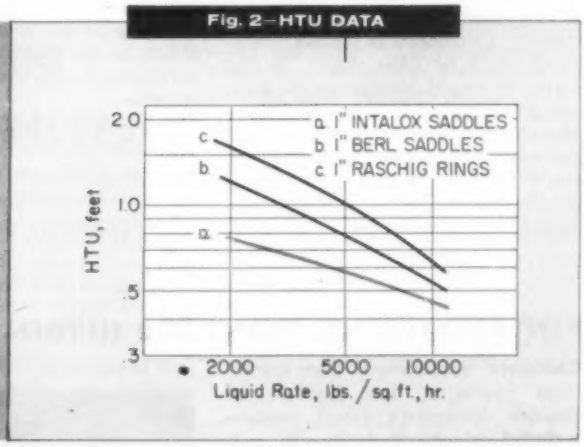
This ability to give higher liquid rates without flooding is reflected in substantially better mass transfer performance.

Fig. 1—HOLD-UP DATA



Higher liquid hold-up of Intalox Saddles reflects the better accessibility of the packing surface to liquid, thus greater wetted-surface area. Voids remain open, pressure drop low.

Fig. 2—HTU DATA



The capacity data shown are typical for a system where both gas and liquid film resistances are involved. Lower HTU values mean shorter towers, less pressure drop and reduced initial investments.

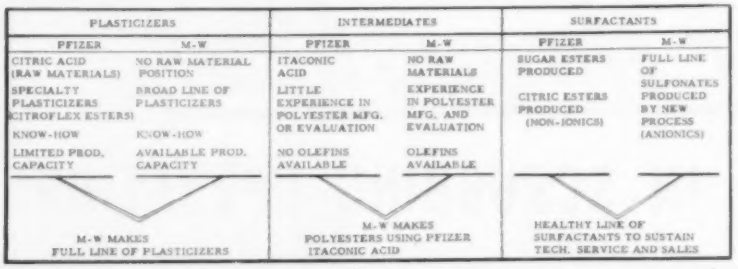
Write for this free booklet:

Bulletin S29-R gives full technical data on Intalox Saddles, performance charts, typical problems and solutions. Address: Dept. CEP-358 U. S. Stoneware, Akron 9, Ohio.

U. S. STONEWARE

AKRON 9, OHIO

481-E



How Pfizer's new Morton-Withers Division will integrate with the company's present product line and future development potential.

THREE-WAY GAIN AT PFIZER

Purchase of Morton-Withers Chemical Co. gives Pfizer a long-sought olefin raw material source, a new, proven sulfonate process, and a broader product line. Morton-Withers is now a division of Pfizer, will be integrated with Pfizer's present product lines.

Primary reason behind the purchase of specialty petrochemical producer Morton-Withers by Chas. Pfizer & Co., major drug and pharmaceutical firm, was Pfizer's need for a source of low-cost olefins to react with itaconic acid and other of its fermentation products. But Pfizer got a double bonus: a new process for producing sulfonate surfactants, and a broad line of plasticizers to combine with its own specialty line of citric acid based plasticizers.

While Pfizer is best known today as a pharmaceutical and agricultural chemicals producer, its original products were fermentation-based chemicals for the chemical, food and beverage industries. Pfizer still is a large chemical producer, with a good business based on organic synthesis, but the company has been handicapped by a lack of low cost raw materials for developing new products. The answer —olefins.

Pfizer had, at first, little interest in Morton-Wither's current line of products, but it did have strong interest in the olefin raw materials used by M-W,

(*Continued on page 92*)

TOTAL INDEPENDENCE FROM NATURAL RUBBER SOURCES NOW POSSIBLE

An Army research report, recently released by the Dept. of Commerce, has confirmed that Firestone's Coral rubber, a cis-polyisoprene, is "practically identical to natural rubber." While the report of the Quartermaster R&D Command neither approves nor disapproves Coral or any other synthetic rubber for use, it does state definitely that Coral *does* duplicate natural rubber, and says "it is expected that the new synthetic rubber evaluated in this report will meet the use requirements formerly satisfied only by natural rubber." The other two polyisoprene rubbers already under development, Goodrich's Ameripol SN, and Goodyear's Natsyn, were not tested, but they are both polyisoprene rubbers aimed at duplicating the natural rubber molecule, and Quartermaster R&D will undoubtedly study them in turn as sufficient quantity becomes available.

Problem: to develop large-scale methods of production for polyisoprenes, which is tied closely to the present low supply of isoprene (only present commercial producer is Esso, and its associated companies, for use in Esso's butyl rubber). As the Quartermaster report put it, "development of large-scale methods for producing Coral rubber may make it possible to reduce stockpiling of natural rubber."

Goal: Independence of foreign sources which are both vulnerable and politically unstable; and reduced stockpiling which means a saving of some $20 million annually.

PENTAERYTHRITOL PLANT FOR HEYDEN NEWPORT

Complete automation, and continuous operation, are features of Heyden Newport's latest pentaerythritol plant. Capacity—25 million pounds.

Salicylaldehyde plant also in works, a new process will be used in this installation.

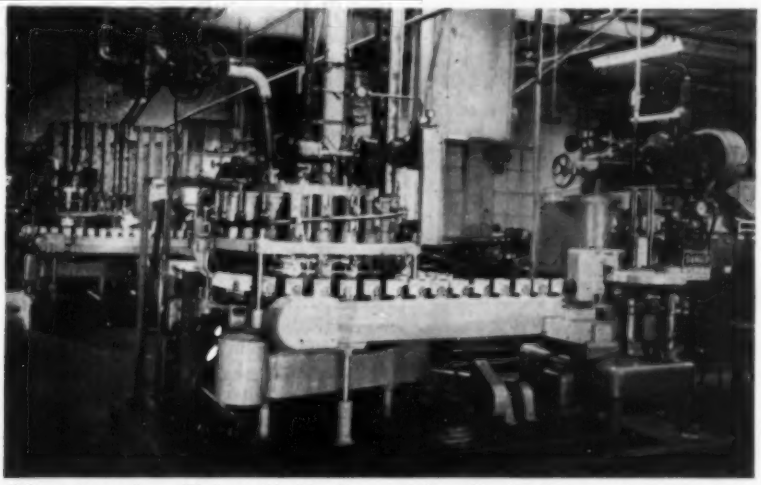
The formal opening of Heyden Newport's new 25 million pound pentaerythritol plant took place recently in Fords, N. J. The multi-million dollar plant is part of Heyden Newport's $25 million expansion program, will strengthen the company's position as the world's largest producer of pentaerythritol.

At the same time, Heyden Newport announced that it will shortly complete a major facility for the production of salicylaldehyde by a new process.

(*Continued on page 96*)

Automated and continuous is the claim of Heyden Newport for its new pentaerthyritol facility at Ford's, N. J. Capacity is 25 million pounds a year for the new installation (white building in the foreground).

PFAUDLER
CORROSIONEERING NEWS



425 quarts a minute filled on this Pfaudler 21-station lube filler at Texaco plant. A total of three Pfaudler fillers handle all lube packaging requirements of the Port Arthur plant.

Filling without spilling at Texaco to 99.9969% accuracy

Texaco uses just three machines at its Port Arthur plant to fill a complete line of motor oils, hydromatic fluids, and antifreeze in quarts and gallons.

Two of these machines — RPL-21 type Pfaudler piston fillers—fill 410 to 425 quarts a minute. They each hold another 65 quarts a minute in reserve capacity. They fill at any viscosity over the complete temperature range 80° to 105° F.

The third machine — an RPL-7 Pfaudler filler — handles gallons at 60 to 80 per minute.

All three machines are accurate to ±0.1 ounce by liquid volume. They eliminate spillage completely . . . send cans from the plant with labels and cartons *clean*. No maintenance is required beyond routine cleaning.

There are only three primary wearing parts on these Pfaudler fillers: piston and valve rollers and valve trip cams. All are inexpensive and easy to replace. There are no connecting rods or wrist pins to cause trouble.

Simple, positive adjustments of the can support rails eliminate product spillage by compensating for the centrifugal forces generated during high-speed filling. An accelerating infeed screw pushes cans in uniformly without jamming.

Cleaning is easy, too. You empty the bowl through a drain port, flush with kerosene, put the machine through a few revolutions, and it's clean.

There's more information about the complete line of Pfaudler fillers offered in the coupon.

This is the most glassed-steel agitated reactor you've ever seen in one piece. O.D.: 120 inches. Height: 125 inches. Capacity: 7000 gallons. Material: glassed steel. It will be used to process monochloroacetic acid and alcohol at 158° F. The jacket is designed to take a 25 psi pressure at 350° F. This vessel uses a conventional three-blade impeller *without a foot bearing*. The agitator is set only 10 inches off bottom. *Moral:* We are ready to answer the most unusual process requirements and to glass any vessel from one-gallon lab units to giants like this. *For the record:* We've made vessels up to 35,000 gallon capacity for large volume storage and these are glassed, too!

New flush valve boasts one-piece glassed head and stem

When we took all the porcelain out of this bottom outlet flush valve, we eliminated a major cause of valve failure.

Head and stem are *one piece and glassed*. No cement. The seat is made of rigidized Teflon-glass fiber and its bevel mates with that of the spherical head. Rubbing the glassed head on the Teflon seat produces absolutely no static. The Teflon also has some "give" so you can get a firm seating without danger of cracking the head covering, a continual problem with the old porcelain designs.

We don't have to tell you of the positive and leakproof sealing you get with this ball-joint construction. And it's probably equally self-evident that the rounded, glassed head eliminates product build-up during processing.

So all there is left to tell is that the new design is interchangeable with existing valves you might now be using and that the unit costs no more than a conventional stainless steel valve. Sizes range from 1½ by 1 to 8 by 6 in six different models.

Anything else you might want to know is covered in Data Sheet 42 which is offered in the coupon.

THE PFAUDLER CO.
a division of
PFAUDLER PERMUTIT INC.
Dept. CEP-38, Rochester 3, N.Y.

Please send information on ☐ Bltn. 878 RPL Oil Fillers; ☐ DS-42 Flush Outlet Valve; ☐ Bltn. 947 Buyer's Guide.

Name .....

Title .....

Company .....

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City ..... Zone ..... State .....

LOWER YOUR VACUUM PUMP MAINTENANCE COSTS

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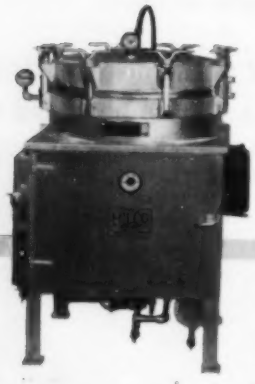

HILCO OIL RECLAIMER

HILCO Oil Reclaimer purifies vacuum pump oil by continuous recirculation, either on a full-flow or by-pass basis, or intermittently on a batch basis, depending on the requirements and physical layout of your plant.

HILCO OIL RECLAIMER SYSTEMS are the finest available for VACUUM PUMP users . . .

A simple, economical and efficient method of restoring contaminated lubricating and sealing oil to the full value of new oil. A HILCO will produce and maintain oil free of all solids, sludge, acid, moisture, solvents, and dissolved gases and it will restore viscosity, dielectric strength and other specifications to new oil value. HILCO oil reclaimers are in wide use for purification of vacuum pump oil in many manufacturing operations.

THERE'S A HILCO FOR EVERY OIL PURIFICATION JOB . . .

• SPECIAL FEATURES •

- CONTINUOUS, ALL ELECTRIC, AUTOMATIC OPERATION
- LOW OPERATING TEMPERATURE
- VACUUM PROCESSING
- INFREQUENT OPERATION, LOW OPERATING COST

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FOR COMPLETE DETAILS, WRITE FOR BULLETIN R-160.

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INDUSTRIAL NEWS

PFIZER

(*Continued from page* 90)

and in a new process for oil-soluble sulfonates ready to be developed by M-W. So Pfizer took a year's option on M-W, advanced the capital to prove-out the new process. The process proved practical and Pfizer bought M-W for 28,000 shares of Pfizer stock.

Integration of New Division

Now a division, M-W is being integrated into a 21-part, 10-year end program of Pfizer's, aimed at developing new products, probably involving olefins, and related to current Pfizer products and know-how in fermentation.

One of the first plans in the works is detailed research and development on reacting olefins, or polyolefins, with the double bond in Pfizer's fermentation-produced itaconic acid to produce practical plasticizers or surfactants. Another possible path is trying to combine some of Pfizer's Citroflex line of non-ionic surfactants with M-W's line of anionic surfactants.

At present, the major combined effort seems to be the production of sulfonate surfactants produced by M-W's new process (still under wraps, patent not yet applied for). A large-scale semi-works plant has just gone on stream, capacity is 10 million pounds a year of sulfonates. The major products are barium sulfonate, calcium sulfonate, and sodium sulfonate—all with a molecular weight of about 500 (based on free sulfonic acid). Pfizer claims these sulfonates are superior materials, have longer chains, are the primary products of the new M-W process, rather than by-products of detergent alkylate production as they are with other producers.

In general, the M-W sulfonate process consists of olefin polymerization, alkylation, sulfonation, and neutralization to produce the heavy alkylates sold. These are all low cost and primary unit processes Pfizer expects to find use for in developing new products in combination with raw materials produced by fermentation.

Pfizer plans to pay off this plant quickly, depending on the quality of the product, and then build a much larger plant somewhere on the Gulf Coast close to an olefin raw material supply.

Three Way Gain

The net result of Pfizer's purchase of M-W is seen in the table:

- By combining its own line of special plasticizers with M-W's broad

(*Continued on page* 94)

VANTON *notes on fluid handling*

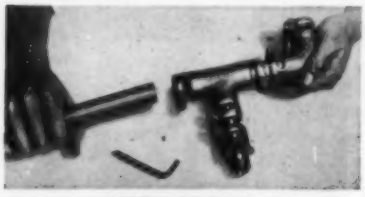
PUMPS • PIPE • FITTINGS • VALVES

NEW QUICK COUPLING STAINLESS FITTINGS CUT TIME AND COSTS

Shulton, Inc., Clifton, N. J. manufacturers of the Old Spice line of men's grooming aids, recently faced the problem of setting up a 1300 ft line of 1" stainless steel tubing over a two-day week-end. They did it by using Quickupl, the new patented stainless fittings requiring no threading, welding, flaring, or heavy-wall pipe.

Since the lines to be put up were practically all overhead and had many take-off points to valves, tanks, and pumps, Shulton realized that standard threaded or welded fittings would take too much time, and disrupt production. With Quikupl couplings, elbows, and adapters two men set up the entire line in less than one day. The only tools required were a pipe cutter and an Allen wrench. This effected considerable savings in labor and substantial material economies by enabling the use of thin-walled tubing.

Quikupl fittings are a natural to use where rapid installation is required. In addition they are 100% salvageable, particularly suited for lines requiring constant changes. Furnished in sizes from 1"-4", Quikupls are available in types 304 and 316 with a variety of seal rings to handle a wide range of corrosives. Write for BULLETIN 312.



New Literature:

Plastic "Flex-Plug" Gate Valve. Four-page folder includes detailed description and operational features of unique plastic gate valve. Technical data and dimensions are included. BULLETIN 313.

Technical Literature:

Folder offers nine items of technical literature on corrosion-resistant pumps, pipes, valves, and fittings. BULLETIN 314.

Pump leakage and metal contamination eliminated by plastic sealless pump construction

Pump problems on corrosive slurry removed by unique Vanton design

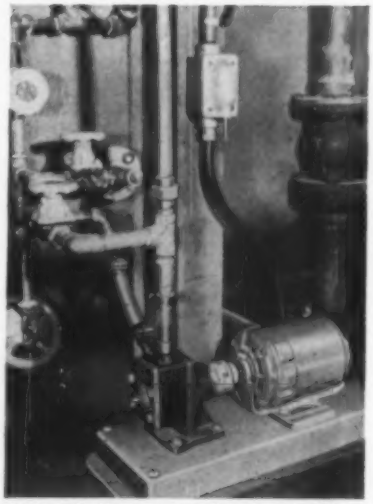
Product contamination, abrasion, and leakage problems at the Reheis Company's pharmaceutical chemicals plant in Berkeley Heights, N. J., were solved recently by installation of Vanton plastic sealless pumps. At Reheis, production of high-purity aluminum hydroxide gels, chlorhydroxide, and related fine chemicals demands the highest quality standards.

In one phase of the operation, pump problems threatened this quality requirement. Here Chlorhydrol and Chloracel fluids, running to 5% abrasive slurries, are recirculated through pH electrode assemblies. pH readings range from strongly acidic to strongly basic. The typical metal rotary pumps that were formerly used caused product contamination. Excessive maintenance was also encountered due to general corrosion and shaft scoring by the abrasive fluid, leading to costly seal leakage.

These problems were solved when Reheis purchased Vanton Buna N Plastic sealless pumps. Contamination was eliminated because no fluid touches metal parts, and leakage and abrasion problems were avoided by the pump's design with no stuffing boxes or shaft seals. Further, abrasion problems were avoided because the flexible liner absorbs the abrasive action of the slurry.

How Vanton Pump Works:

With stuffing boxes and shaft seals eliminated by the unique design, leakage is no longer a problem. Metallic contamination is impossible,



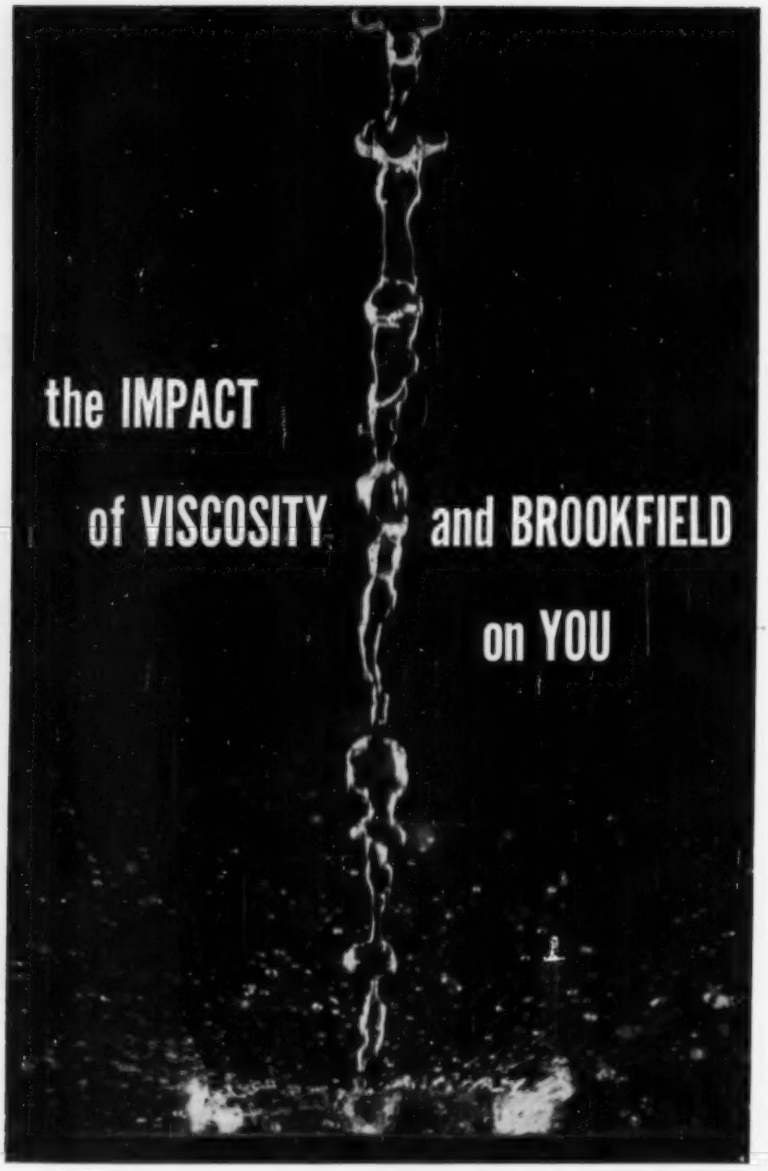
Vanton plastic pump handles corrosive abrasive slurry at Reheis Co., Berkeley Heights, N.J.

since the fluid cavity of the pump is formed by the inside of the channeled plastic housing and the outside of the synthetic liner. Flanges on the liner, clamped to the sides of the housing

by end plates, isolate all fluid to this cavity. Pumping is accomplished by a rotor mounted on an eccentric shaft, which rotates within the liner, creating a progressive squeegee action on the fluid trapped between the liner and the housing.

Capacities of the Vanton sealless plastic pump range from ½ to 40 gpm. Liners and housings are made in a variety of plastic materials, to suit a wide range of corrosive, acid, and slurry conditions. For further details, write for CATALOG 311.

VANTON PUMP
and Equipment Corp. • Hillside, N. J.
DIVISION OF COOPER ALLOY CORP.



Like color, pH, stability and composition, the flow properties of any material . . . its Viscosity . . . is a product dimension which can't be ignored! Accurate viscosity measurement, evaluation and control can turn chance to science . . . waste to wealth.

Today, thousands of profitable processes depend upon accurate viscosity control and upon Brookfield viscosity measuring instruments. A fully-descriptive brochure — devoted to viscosity in general and illustrating Brookfield viscometers and allied equipment is yours without obligation. Write today!

The World's Standard for Viscosity Measurement and Control

Brookfield ENGINEERING LABORATORIES INCORPORATED
STOUGHTON 18, MASSACHUSETTS

INDUSTRIAL NEWS

PFIZER

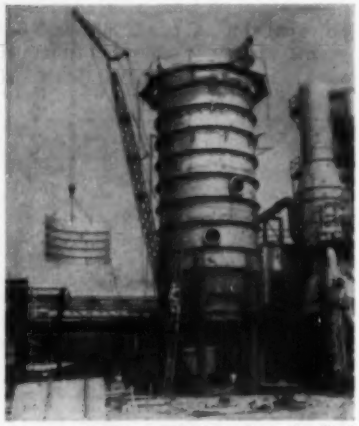
(*Continued from page 92*)

line of general plasticizers, Pfizer gained a wide product line to sell; and adequate facilities to produce its own line of plasticizers which it did not have.

- Pfizer had the double-bonded itaconic acid, but no experience or facilities for reacting itaconic. M-W had the experience and the facilities for polyester manufacture. Now Pfizer can go ahead with its work leading to fermentation product-olefin product combination.
- In the surfactant field, Pfizer gained a good process, a broader market line, and the potential combinations of fermentation products and olefin products.

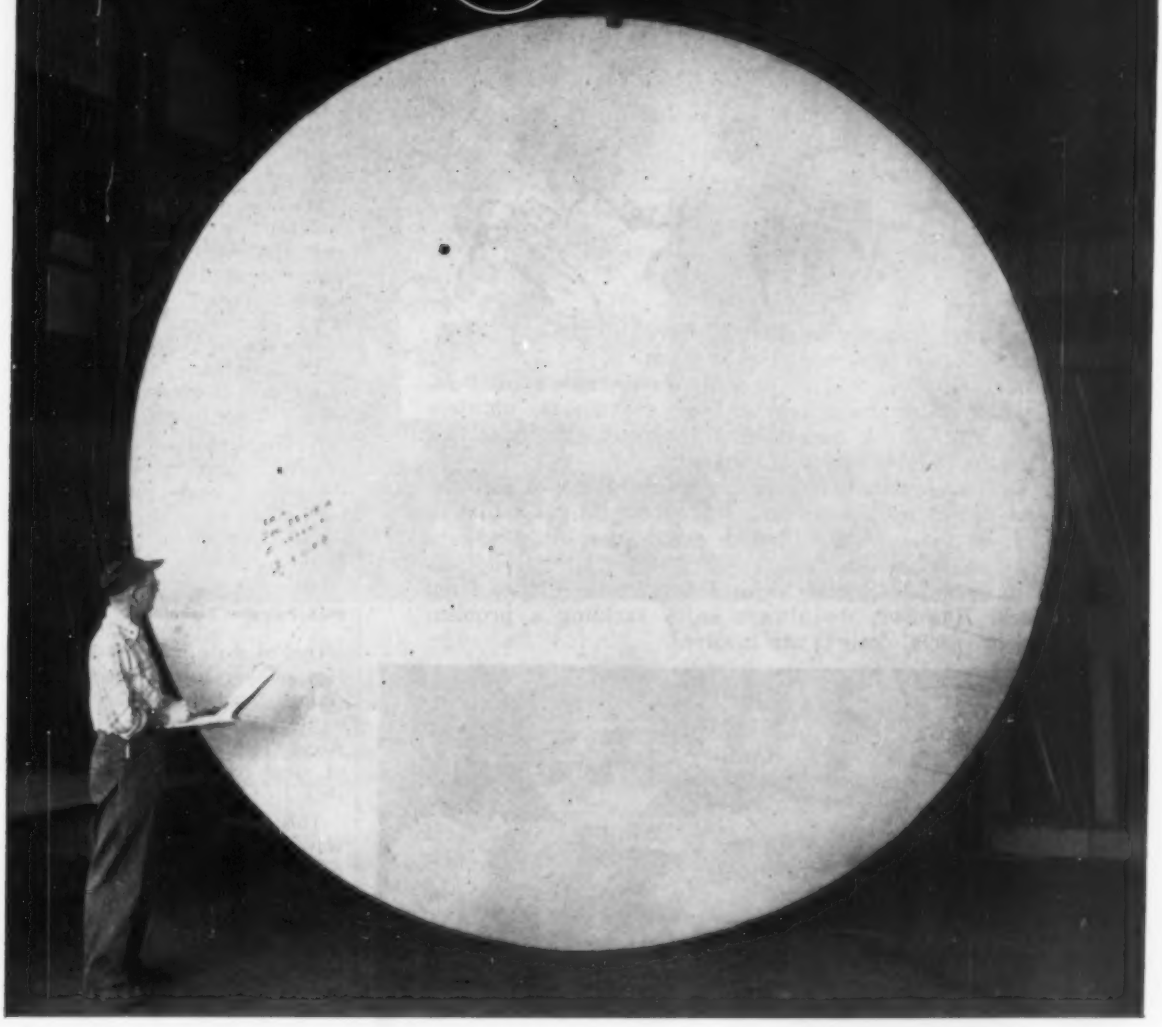
A computer-controlled pilot plant to aid development of new refining processes will be acquired by Esso Research and Engineering at Linden, N.J. The automatic miniature plant, which will fit into a 10 by 12 foot room, is now being built by Consolidated Electrodynamics in cooperation with Esso. □

Hercules Powder's plans for a methacrylate plant at Louisiana, Missouri, announced last year as a joint venture with Imperial Chemical Industries Ltd., England, have been abandoned. Reason for the decision was not pinpointed. Said a company spokesman: "After careful study it has been decided the project is currently unattractive to us." □



Shown at the Hopewell, Va., plant of Allied Chemical & Dye, National Aniline Division, is the world's largest stainless crystallizer. Weighing more than 150 tons, 82 ft. high and 20 ft. in diameter, the unit will process more than 300 tons of ammonium sulfate daily. Fabricator was Struthers Wells.

WHY BUY STAINLESS STEEL squares WHEN IT'S circles YOU NEED?



This circle, 9/16" thick x 164" diameter, is one piece of Type 316L stainless steel. Had the customer ordered a square, he would have paid freight on a half-ton of excess material. Also, he would have had the problem and expense of handling the square and cutting the circle.

Here are four sound reasons why Carlson customers save time and money when they order the circles they want—rather than the squares they have to cut . . .

1. If the gauge and size are circle-shearable, there is no extra charge for cutting the circle. This saves cutting labor and scrap handling expense.
2. If the gauge is such that a cutting charge applies to the square, it pays to order the circle. This eliminates the extra charge for cutting the original square and involves only the one charge for cutting the circle.
3. Because circles weigh approximately 25% less than squares, there's a substantial saving in transportation costs.
4. Small or medium size circles are often available from stock when squares may not be. The delivery time saved can be an important factor.

When you need stainless steel circles, come to Carlson where we specialize in stainless steel . . . that's your guarantee of dependable service.

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District Sales Offices in Principal Cities

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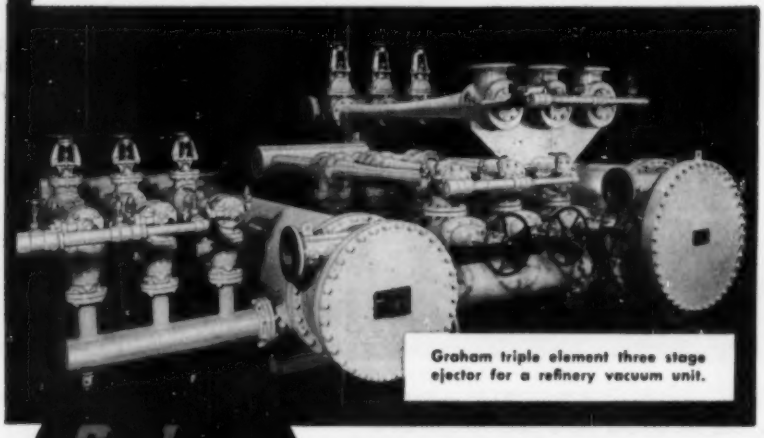
Quick Eddie, get the shovel —we've ruined another batch!

The above calamity might well have been caused by unreliable vacuum producing equipment — *and there's where we come in.* Graham Ejectors guarantee you continuous, uninterrupted and stable operation; for certain, it's industry's most dependable source of vacuum.

Graham ejectors are built for the full range of absolute pressure to below 1 micron, either steam or gas actuated, and we believe that further exploration will indicate additional progress.

Our standard ejector equipment may be shipped from stock. However, we always enjoy tackling a problem where special designs are involved.



Graham triple element three stage ejector for a refinery vacuum unit.

Graham MANUFACTURING CO., INC.

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Factory trained engineers are available in these cities:

Baltimore, Md.	Detroit, Mich.	Philadelphia, Pa.
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Buffalo, N. Y.	Houston, Tex.	Roanoke, Va.
Chicago, Ill.	Kansas City, Mo.	San Francisco, Calif.
Cincinnati, O.	Los Angeles, Calif.	Seattle, Wash.
Cleveland, O.	Mexico D.F., Mexico	St. Louis, Mo.
Coral Gables, Fla.	Minneapolis, Minn.	Toronto, Ont.
Denver, Colo.	Mobile, Ala.	Tulsa, Okla.

INDUSTRIAL NEWS

PENTAERYTHRITOL

(*Continued from page* 90)

At present under wraps, the new process will be catalytic, and will involve a departure from conventional methods of production. The plant will produce over a million pounds of salicylaldehyde a year.

Automatic, Continuous

In its new pentaerythritol plant the company is also incorporating new process techniques, also secret at present.

The features of the new pentaerythritol plant are continuous operation used wherever it is possible, and complete automation. One operator at a master control board regulates all raw material flows; all temperatures, mixing speeds, and time and rate of reactions. Process control is assisted by a system of interlocks and warning signals on the control panels.

An unusual feature of the new plant is that more than half its process equipment is located outside the building for safety reasons—not a common practice for chemical plants in the north.

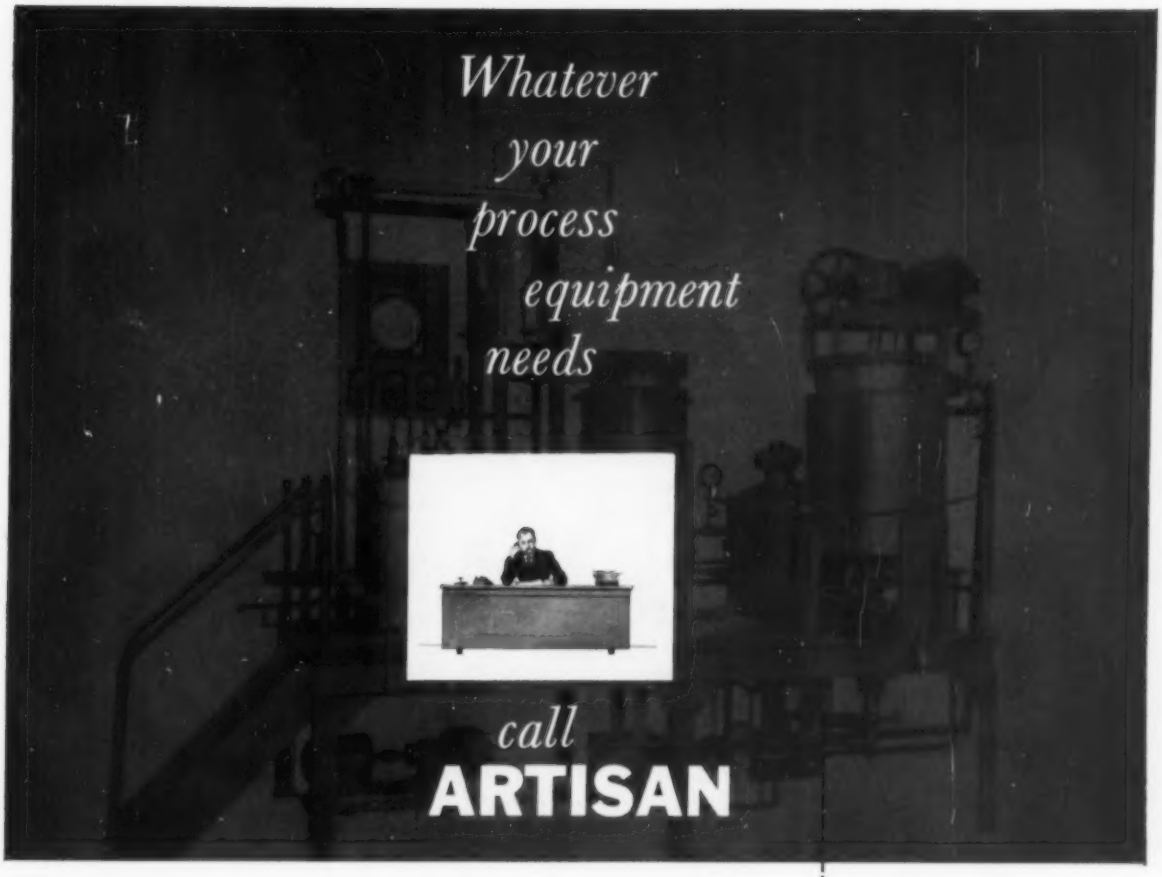
High Polymer Technique

One of the primary factors behind Heyden Newport's expansion of pentaerythritol capacity at this time is its own development of the High Polymer Alkyd Technique for the production of alkyd resins based on pentaerythritol.

This relatively new technique involves the formation of a greater proportion of high molecular weight alkyd fractions by a stepwise esterification of the fatty acids in the alkyd formulation. The resin is prepared by reaction of all the polyol and all of the dibasic acid with an initial quantity of fatty acid, esterifying to a low acid number, and then adding the remainder of the fatty acid and again esterifying to a low acid number.

The company claims that the viscosity of this type of alkyd is higher than usual, the resin colors are frequently lighter, and there is a considerable increase in the dry rate and alkali resistance properties.

Doubled production of ethylene oxide and propylene oxide is announced by Wyandotte Chemicals as its new oxide products plant at Wyandotte, Mich., goes on stream. □



Whether you need a single piece of process equipment or a complete pilot plant tailored to your specifications, the shortest, most economical distance between problem and solution is a call to your Artisan representative. Here are 3 practical reasons why:

1... Artisan offers *complete service* — from design through manufacture. Artisan's large staff of chemical and mechanical engineers is experienced in all phases of process equipment design.

2... Artisan offers *superior manufacturing capability.* Ample facilities, modern equipment, manned by skilled craftsmen who have spent a quarter century turning out quality equipment for the process industries.

3... Artisan offers *economy, on-time delivery.* Complete, one-stop service, with careful control at every step makes possible important economies all along the line, insures delivery as promised.

You'll find that Artisan *cooperates,* whether your problem is large or small. So phone today — or, write direct. You'll get a speedy, specific reply at no obligation.

FREE — *Fact-packed folder gives complete information on each of Artisan Industries' many services. Invaluable reference material for anyone who will ever need process equipment. Write for your copy today.*

Specialists in process equipment and pilot plants — Evaporation • Distillation • Waste recovery • Heat transfer • Solvent extraction and recovery • Organic synthesis • Nuclear process equipment

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THE KONTRO COMPANY, INC. — Ajusto-film centrifugal process equipment • Thermalizers

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METAL FABRICATORS CORPORATION — Skilled metal fabricating for chemical, electronics and aircraft industries. Specialized components for machine tool industry

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HI-SPEED EQUIPMENT, INC. — Manufacturers of film processing equipment

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ARTISAN INDUSTRIES

DEMAND FOR ENGINEERS EXCEEDS SUPPLY IN 1957—BUT GAP IS LESSENING

Just released survey on the Demand for Engineers, conducted by the Engineering Manpower Commission of Engineers Joint Council.

The sample (about 1200 companies and Government agencies) used in EMC's survey for 1957 reports an overall need for engineers exceeding the number they anticipated being able to hire during that year. But this deficiency is less than that reported in 1956.

A special part of the survey, however, indicated that the chemical and allied industries still have the second highest gap between engineers needed and engineers they expected to be able to hire.

The table shows the picture for 1957. Starting on January 1 with a total of 175,583 employed engineers in the industries surveyed, and an expected loss of 15,130 engineers through retirement and other means, industry and government needed a supply of graduate and non-graduate engineers totalling 33,156. They expected to get a total of 26,687, leaving a deficit of 6,469 engineers who would not be available although needed.

DEMAND AND ANTICIPATED SUPPLY OF ENGINEERS—1957

	Required Supply			Expected Supply		
	Industry	Gov'mt.	Total	Industry	Gov'mt.	Total
Employed, Jan. 1, 1957						
Eng. Graduates	120,055	27,399	147,454	120,055	27,399	147,454
Non-graduates	19,302	8,827	28,129	19,302	8,827	28,129
Total	139,357	36,226	175,583	139,357	36,226	175,583
Expected Losses	11,125	4,005	15,130	11,125	4,005	15,130
Source, New Employees						
Current class: BS	11,136	4,569	15,705	8,659	2,227	10,886
MS	1,275	255	1,530	1,062	173	1,235
PhD	678	33	711	496	6	502
Total	13,089	4,857	17,946	10,217	2,406	12,623
Earlier Classes	8,878	2,970	11,848	8,377	1,874	10,251
Other sources	2,238	1,124	3,362	2,753	1,060	3,813
Grand Total	24,205	8,951	33,156	21,347	5,340	26,687
Net Hired (Hired-Losses)						
Graduates	13,253	4,567	17,820	9,880	1,020	10,900
Total	13,080	4,946	18,026	10,222	1,335	11,557
Expected Employed, Dec. 31, 1957						
Eng. Graduates	133,308	31,966	165,274	129,935	28,419	158,354
Non-graduates	19,129	9,206	28,335	19,644	9,142	28,786
Total	152,437	41,172	193,609	149,579	37,561	187,140

The 1957 graduating class of engineers was, according to EMC's survey, 20 per cent larger than the 1956 class, or a total of 31,000 engineers. A greater proportion of these graduates were immediately available due to lessening military demands, deferment procedures, and the Critical Skills Program. The net result was to increase the percentage of available new graduates by about 25 per cent. The graduating classes for the next few years are expected to continue to grow steadily. At the same time, progress has been made in increasing the productivity of engineers. Thus, it is valid to conclude that there will be some reduction in new supply needs.

Industry Down—Government Up

The demand for engineers in industry appeared to be substantially the same in 1957 as in 1956, and industry seemed to anticipate less difficulty in filling its demands. An important side-issue was the apparent decreasing significance of non-graduate engineers. The ranks of non-graduates are being depleted at a faster rate than the graduate group, while being replaced at a much lesser rate.

Thus, the results of the 1957 survey indicate that there was a measurable downward trend from 1956 in the demand for engineers in industry. But this was partially offset by a rising demand on the various levels of Government.

Government deficiencies between needs and supply were about 31 per cent in 1956, and 51 per cent in 1957. The Federal Government has been encountering difficulty in recruiting new

(*Continued on page* 102)

SURVEY SHOWS SIXTY PER CENT OF RESEARCHERS ENGAGED IN ENGINEERING RESEARCH

Based on a final analysis of figures gathered and compiled by The National Science Foundation for the year 1954, a new survey shows that there were 139,200 engineers, and 89,800 physical and life scientists engaged in R&D in the institutions surveyed.

These totals were about 25 per cent of the engineers employed in all activities by the reporting organizations, and about 40 per cent of the scientists employed by the same organizations. Obviously, while there were more engineers doing R&D than scientists, a far larger proportion of scientists go into R&D than do engineers.

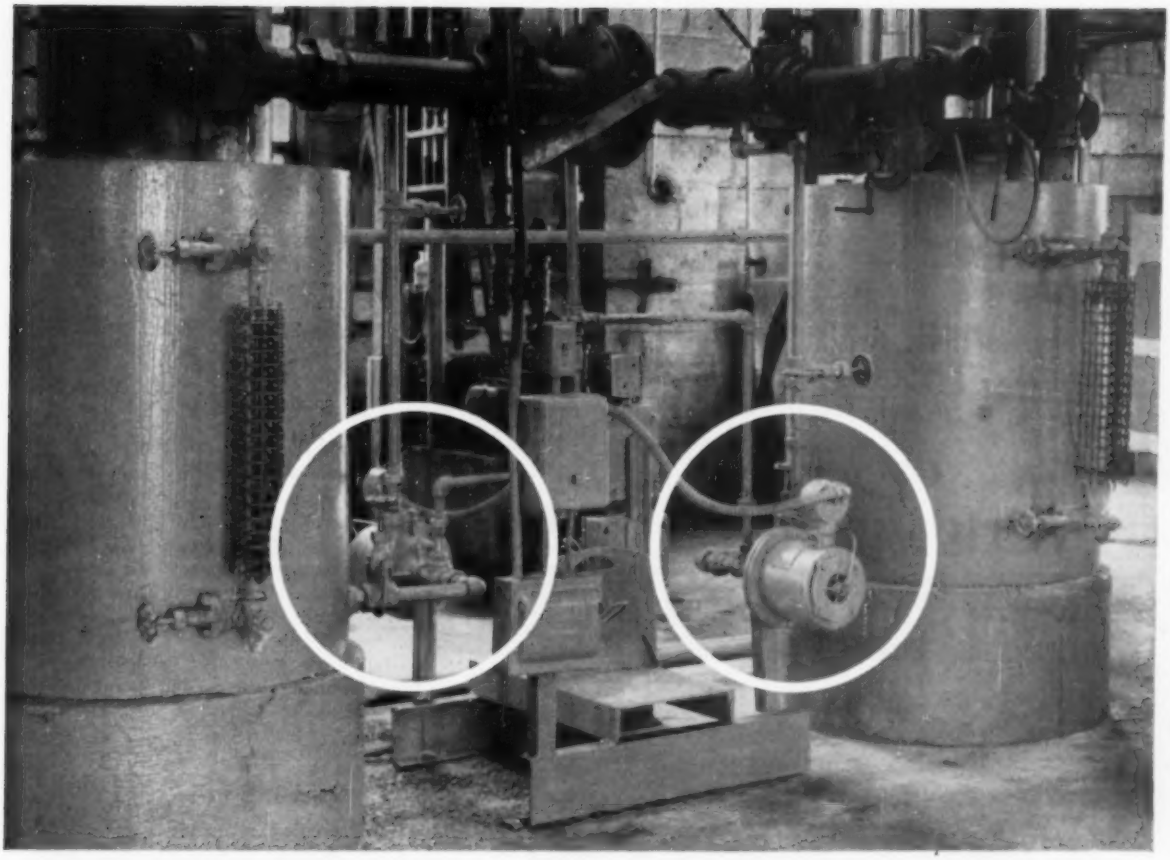
Some 60 per cent of the research-engaged personnel were working in engineering research. The physical

(*Continued on page* 100)

SCIENTISTS AND ENGINEERS ENGAGED IN R&D—1954

Employing Group	Physical Sciences	Engineering	Life Sciences	Total
Federal Government	13,800	16,700	4,800	35,300
Industry	45,700	116,600	4,200	166,500
Colleges & Universities	7,600	5,600	12,000	25,200
Other Institutions	700	300	1,000	2,000

Source: National Science Foundation



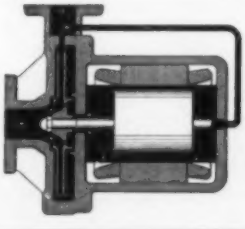
Chempump eliminates frequent shutdowns

handling hot caustic at Delmar Chemical Company

These two *Chempumps* are on the job 24 hours a day, 7 days a week at Delmar Chemical Company, Elkton, Md. They circulate caustic through scrubbing towers for gas purification, and have completely eliminated excessive shutdowns caused by conventional pump stuffing box and seal problems.

These dependable, leakproof pumps are out of operation only for a simple annual replacement of bearings, their only wearing parts. *Chempumps* have no seals, no stuffing box, no packing. No external lubrication is needed, since bearings are constantly lubricated by the pumped fluid itself. Caustic can't leak out and air cannot enter the pump.

Chempump offers many exclusive advantages in any chemical handling application. It would be well worth your while to check them. For details concerning your specific application, write to Chempump Corporation, 1300 E. Mermaid Lane, Philadelphia 18, Pa. Engineering representatives in over 30 principal cities in the United States and Canada.



Chempump combines pump and motor in a single, leakproof unit. No shaft sealing device required.

U.L. approved. Available in a wide choice of materials and head-capacity ranges for handling fluids at temperatures to 1000 F. and pressures to 5000 psi.

Chempump

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If ... time is a factor...

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INSTITUTIONAL NEWS

ENGINEERS R&D

(*Continued from page* 98)

sciences and engineering accounted for 90 per cent of the total.

The composition of the research staffs of industrial organizations contrasted sharply with the composition of the staffs of educational institutions. In industry, engineering and the physical sciences predominated, while in educational institutions almost half the researchers were working in the life sciences. If colleges and universities were considered alone, without the staffs of Federal contract research centers, then the proportion of life science work was even higher—58 per cent.

Over 70 per cent of the research scientists and engineers were employed by industry, with some 15 per cent employed by the Federal Government, and 11 per cent by educational institutions. Of the Federal Government total, military scientists and engineers constituted about one-fifth, or 6,800. Here again, engineers were in the majority—4,500.

Conceptual Problem

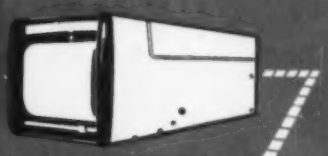
A problem encountered in this survey stemmed from conceptual differences with respect to "research and development."

The problem in defining R&D came from the question of the "cut-off" point. In educational institutions and the Federal Government, design and development work involved with such matters as prototype plants after initial research had been completed, was not considered R&D. But in industry, design and pilot or prototype development were considered to be R&D. This means that certain engineers and scientists doing work for the Federal Government in design, etc., are not included in the survey, whereas they are if they worked for industry.

A Master of Engineering Administration degree is now being granted by George Washington University's School of Engineering, Wash., D. C. Since engineers and scientists are finding increasing opportunity, or demand, to enter administrative ranks, George Washington is offering this course to help them prepare. The program is designed for men who hold engineering degrees, and who have advanced in their careers to the point of having or anticipating administrative responsibility.

This pneumatic flow control gives

LIVE-ACTION RESPONSE . . . 1000 feet from panel!



Complete elimination of controller-to-valve response delay! True close-coupled control even when the operating panel is *hundreds* of feet away. These are big features you'll find in the Foxboro Model 59 flow control system.

The M/59 is the only controller specifically designed for direct mounting on the control valve motor. Need for brackets and controller-to-valve piping is eliminated. This unique force-balance controller has only two moving parts. There's no explosion hazard with this all-pneumatic system. And there are no bearings; no linkages – nothing to align or go wrong.

Learn how the fast response and simple adjustment of the low cost M/59 Controller, teamed up with the Foxboro d/p Cell Transmitter, will improve control of your process flows. Write today for Bulletin 470.

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and Eco is the only manufacturer who has made it available. The first self-priming rotary gear pump suitable for non-lubricating and corrosive fluids is now available for immediate delivery. The pump, with ¾" P.T. inlet and outlet ports, features housings of 316 or Carpenter 20 stainless steel, Hastelloy C or nickel, with reinforced Teflon gears and internal Teflon bearings and packing.

*Designated the GearChem**, this pump is suitable for speeds to 1750 rpm at capacities to 10 gpm and pressures to 100 psi. Viscous media to 5000 SSU can be pumped at reduced speeds.

The GearChem created tremendous interest at the recent Chemical Show. In addition to proportioning and metering applications the pump is ideal for general process work in pilot plant and production operations.

Write for prices and complete information.

* T.M. Applied For

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INSTITUTIONAL NEWS

ENGINEERS DEMAND

(*Continued from page 98*)

graduates due, probably, to low starting base salaries in comparison to other opportunities open to them. The Federal Government has also tended to lose a considerable number of experienced graduate engineers.

In short, the various government agencies reflect a much-accelerated need for recent graduates as well as for experienced personnel. However, this is only a relatively small fraction of the total employment of engineers, and only slightly effects the lessening of demand.

Looking Ahead

Based on current trends, and assuming no major departure from the natural long-range growth of need for technological personnel, or changes in expenditure policies by the Defense Dept., EMC interprets its survey to show that the demand-supply ratio may be in close balance for the next few years. EMC feels that increasing emphasis will be placed on quality, and many less productive personnel will find it increasingly difficult to hold engineering positions. Staff standards are being raised now, and the trend will probably accelerate.

Should there again develop a major upward shift in the overall economy, and should current defense expenditures be revised upward, particularly in the missile R&D field, then continued shortages of engineers will exist for some time. But if such things do not develop in significant magnitude, then the shortage of engineers will probably begin to vanish.

Salaries

An incidental by-product of the study was data on engineer's salaries. Broken down by industry, and based on the base starting salaries for men with Bachelor's degrees, the EMC survey indicated that the salaries paid in the chemical industry to beginning graduate engineers did not tend to vary much—highest base starting salary was found to be $465/month, and the lowest was $425/month. But the weighted average base salary for engineers starting in the chemical industry was found to be $434/month, and this was only fourth from the lowest out of 18 industry groups. In short, in 1957, engineers starting in the chemical field earned a base salary lower than that paid engineers in 14 other industries.

ANNOUNCING

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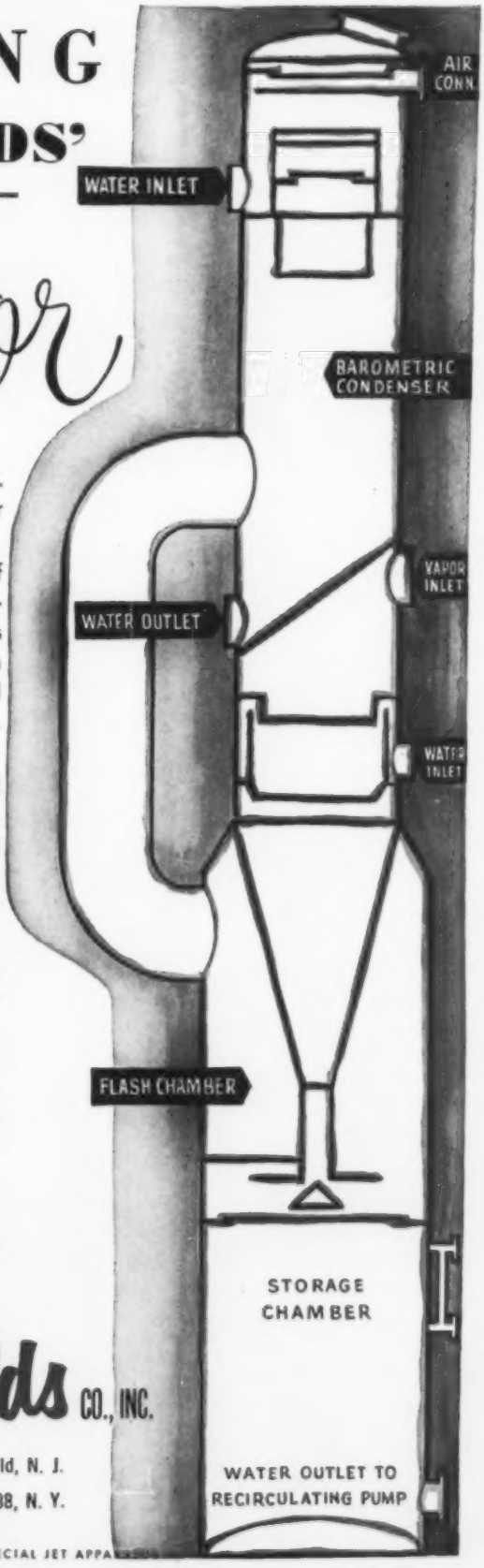
NEW Convactor

If you never heard of a CONVACTOR, do not be surprised. It is an entirely new design of special condensing tower which offers important advantages in some processes.

In the refining of edible oils it recovers fatty acids, most of which were formerly waste. It offers the additional advantage of totally eliminating stream pollution from this source or the expense of cleaning cooling towers which collect such deposits. It has similar application in fatty acid stills, some other types of distillation processes, dryers, and other large vacuum processing units.

The CONVACTOR is a combination of two condensers and a vacuum cooling chamber. One condenser is of conventional barometric design, the other a highly improved condenser working on the jet principle. The latter condenses the vapor from the process and discharges directly into the vacuum cooling compartment where the heat of condensation is immediately removed. The cold water is then recirculated through the same jet condenser. The flashed vapor from the cooling operation is condensed in a conventional barometric condenser using water from a river, cooling tower or other industrial source. Periodic blow-down or continuous bleed-off from the flash chamber permits recovery. Several large industrial installations have been made.

It is significant that this new contribution to vacuum equipment should come the year we are celebrating our Fortieth Anniversary.



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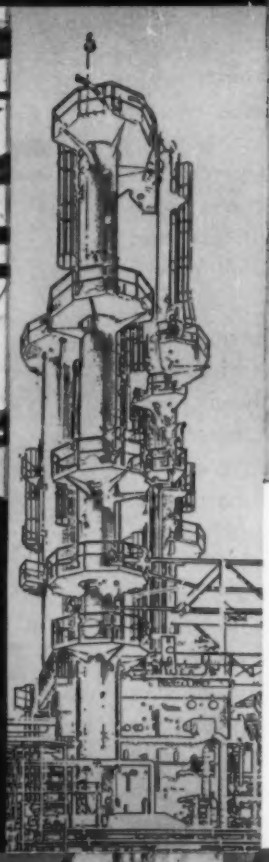

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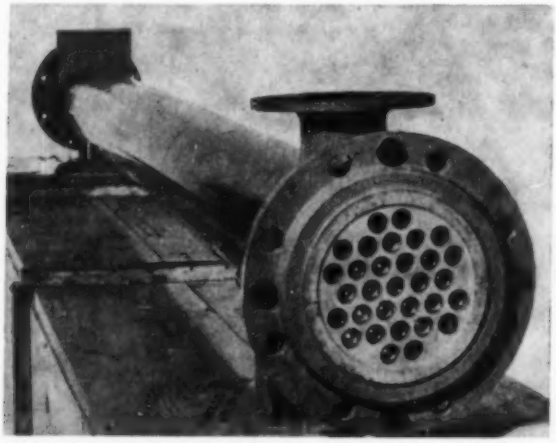
PYREX HEAT EXCHANGER ATTAINS LARGER CAPACITY

(For further technical information, circle number 391 on Data Post Card.)

Seen at the recent Chem Show in New York was an experimental unit of a 60-sq.ft. Pyrex shell and tube heat exchanger for processing corrosive fluids. Product of Corning Glass Works, the exchanger is designed primarily for cooling operations, features glass tubes inside a light steel shell.



The six-inch shell unit contains 31 thin-walled Pyrex tubes in the bundle. A new simplified tube sheet assembly is said to provide easier installation and maintenance and easier mounting of end fittings. Tighter tube packing in the shell has increased outside film coefficient by more than 12%, according to Corning.

Operating temperatures up to 200° F. on the shell side of the heat exchanger and up to 375° F. on the tube side are possible. Operating pressures can be as high as 20 lb./sq.in. Overall values of U have been measured up to 213 B.t.u./hr./sq.ft./° F. in water-to-water tests. For further information, circle number 391 on the Data Post Card.

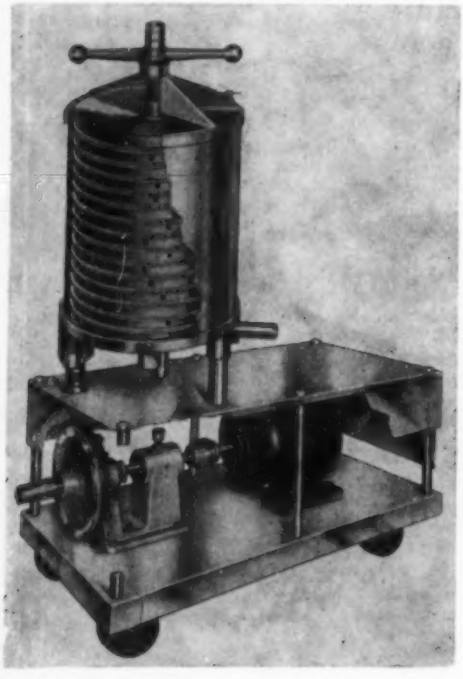
NEW ENTRAINMENT SEPARATOR DESIGN

(For details, circle Number 393 on Data Post Card)

A newly-designed entrainment separator, the WD Scrubber made by Centrifix Corp., is guaranteed to remove 99.5% or more of solid or liquid entrainment in gas or vapor, regardless of size, density, or chemical characteristics. The new unit can be designed for any operating pressure, flow rate, or temperature within reasonable operating limits.

In operation, the contaminated gas enters the vessel and spreads out in the lower chamber where it is combined with the scrubbing liquid which is either sprayed on the outside of the tuyere or fed into the base of its inner circumference. Jet action from its passage through the tuyere blades imparts a rotary motion to the gas which mixes it thoroughly with the scrubbing liquid and tends to throw the heavier liquid particles to the outside of the rotating mass.

This liquid portion, including contaminants, is discharged over the lip of the scrubbing tuyere into an annular raceway and out the scrubbing stage drain. The gas leaving the scrubbing tuyere passes upward into a series of tangential slots in the upper or drying tuyere. Here, a similar rotating motion is imparted which throws off any contaminants carried over from the scrubbing tuyere. These contaminants enter a second raceway and discharge through the drying stage drain, leaving only clean gas to move through the outlet of the vessel. For further technical details, circle Number 393 on the Data Post Card.



FILTER PLAYS VITAL ROLE IN HOT LAB OPERATIONS

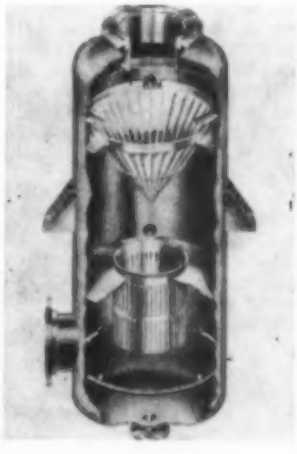
(For further details, circle Number 392 on the Data Post Card.)

Modified sub-micron filter units made by Alsop Engineering Corp. are playing an important part in metallographic analysis of irradiated materials from nuclear reactors.

The liquid employed during the grinding, polishing, and cleaning of the specimens is drained from the polishers into a stainless steel tank located under the working table. The tank is equipped with a liquid level float switch which activates a centrifugal pump when the liquid reaches a set level. As a safety measure, the pump has an override switch which can be manually operated from outside the cell. The liquid is then pumped through an Alsop filter and into a collection tank located outside the cell.

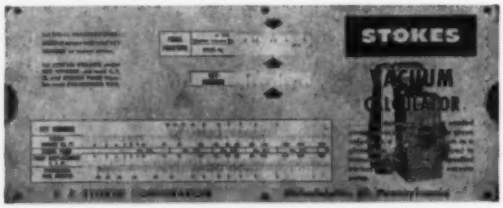
The filter unit itself is packed with 10 asbestos-cellulose filter discs capable of filtering out sub-micron particles. The filter units have been modified so that the discs can be changed with the master slave mechanisms. For further details, circle number 392 on the Data Post Card.

◄ HOT LAB FILTER



NEW ENTRAINMENT SEPARATOR ►

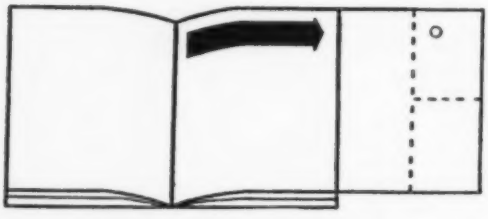
DEVELOPMENTS OF THE MONTH



394 Slide Rule Vacuum Calculator. Handy-sized slide rule offered free by F. J. Stokes Corp., Vacuum Equipment Division, determines quickly the pumping capacity needed to evacuate a given volume to a specified vacuum in a given time, or computes the time required to reach a specific vacuum in a given volume with a pump whose capacity is known. The calculator also displays the vapor pressure of water at various temperatures; the capacities of round tanks of different diameters in cubic feet per foot and gallons per foot; the boiling point of eleven common solvents at pressures from atmospheric to absolute vacuum; melting point and vapor pressure of nine metals frequently deposited by vacuum evaporation; and a useful conversion table for high vacuum computations. To obtain one of these handy calculators circle number 394 on Data Post Card.

JUST A MOMENT is needed to learn how to use this insert. When looking through the front part of the magazine, pull the folder portion of the insert out to the right, and the numbers on the post card are convenient for circling.

THEN . . .



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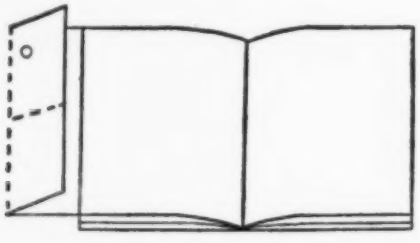

Numbers followed by letters are for checking your interest in the products, equipment, and services advertised in this issue, the number corresponding to the page on which the ad appears. Letters indicate position on the page: L, left; R, right; T, top; B, bottom. A indicates a full page; IFC, IBC, and OBC are cover advertisements. **Numbers in the 300-series** bring you new engineering data in the chemical engineering field.

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in the American Institute of Chemical Engineers are spelled out in the brochure "Know Your Institute," which also outlines the objectives of this nation-wide organization of chemical engineers and includes a membership blank for your convenience. Circle number 399 on Data Post Card.

IFC Storage Tanks. For chemical and petroleum service. Wyatt Metal & Boiler Works.

3R Rotary Sifter Bulletin. B. F. Gump Co.

4A Entrainment Separator Bulletin. Otto H. York Co.

6A Data on Spiral Ribbon Mixers. Read Standard, division of Capitol Products.

7A Fume Scrubbers. Bull. 4R from Schutte and Koerting.

9A Heat Exchangers. Texas Metal Fabricating Co.

10A-11A Motor-Driven Reciprocating Compressors. Ingersoll-Rand.

12A Process Pumps. Bull. EM-79 from Peerless Pump Division, Food Machinery and Chemical Corp.

13A Process Simulation by Analog Computer. Services available from Electronic Associates.

15A Compacting Process. Bull. 07B8836 from Allis-Chalmers.

16L Wire Cloth Catalog. Newark Wire Cloth Co.

17A Water Supply Equipment. Bull. CW-9 from Layne & Bowler.

18A Quick Couplings. Ever-Tite Coupling Co.

23A-24A New Technical Developments. Bull. from U.S. Industrial Chemicals.

25A Pan-Type Filters. Eimco Corp.

26L Processing Equipment Fabrication. Bulls. from Downingtown Iron Works.

27A Processing Equipment. Bulls. from Sprout-Waldron.

28L Polyethylene. Technical data from Semet-Solvay Petrochemical Division, Allied Chemical & Dye.

29A Mercury Arc Rectifiers. Information from Allis-Chalmers.

30L New Pilot Plant Dryer. C. G. Sargent's Sons Corp.

31A Filters. Purolator Products, Inc.

32L Telemetering Systems Booklet. Also Bull. CP-3012 on pulse code telemetering. Vapor Recovery Systems Co.

33A Petrochemical Plants. Blaw-Knox, Chemical Plants Division.

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92L Oil Reclaimer Systems. Bull. R-160 from Hilliard Corp.

93A Stainless Steel Valves. Folder from Cooper-Alloy Corp.

94L Viscometer Brochure. Brookfield Engineering Laboratories.

95A Stainless Steel Circles. G. O. Carlson, Inc.

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99A Leakproof Pumps. Details from Chempump Corp.

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104A Design and Construction Services. Fluor Corporation.

109A Process Pumps. Aldrich Pump Co.

111A Adjustable Proportional Band Liquid Level Control. Engineering Data Sheet from Leslie Co.

113A Process Dryers. Test services available. Louisville Drying Machinery Unit, General American Transportation.

114L Vacuum Ejectors. Bulls. from Elliott Co.

115A Plastic Tower Packing. Booklet from Harshaw Chemical.

116L Woven Wire Belts. Reference manual from Cambridge Wire Cloth.

117A Plant Design and Construction. Badger Mfg. Co.

118L Evaporative Heat Exchangers. Bulls. 129, 130, 132, and 136R from Niagara Blower.

119A Filters. Sparkler Mfg. Co.

120L Agitators. Bull. 551 and data sheet from New England Tank & Tower.

121A Fire Pumps. Bulls. 5841F and 6902F. from Fairbanks-Morse.

124L Vertical Leaf Filters. T. Shriver & Co.

125A Design and Construction Services. Girdler Co., Construction Division.

126L Corrosion-Resistant Vaporizers. Richard M. Armstrong Co.

127A Automobiles. Oldsmobile Division, General Motors.

128L Tantalum Corrosion Test Kit. Fansteel Metallurgical Corp.

129A Oxygen Generating Plants. Air Products, Inc.

131A Centrifugals. Datafile 1285 from Sharples Corp.

132L Mixer Catalog. Baker Perkins, Inc.

133A Fired Heaters. Struthers Wells.

134L Heat Exchangers. Bull. 1000 from Davis Engineering.

135A Compressors. Cooper-Bessemer.

136L Process Equipment. Edw. Renneburg & Sons.

137A Porcelain Valves. Lapp Insulator Co.

139A Catalyst Research Services. Girdler Co., Chemical Products Div.

140L Teflon Gaskets and Expansion Joints. Catalogs from U. S. Gasket Co.

141A Waste Disposal Systems. Booklet from Dempster Brothers.

142L Spray Nozzles. Performance data from Spray Engineering.

143A Design and Construction Services. Booklet from M. W. Kellogg.

144L Alloy Castings. Duraloy Co.

145A Impervious Graphite Entrainment Separators. Catalog Section S-6900 from National Carbon Co.

146L Mixers. Catalog V-1 from Paul O. Abbe.

147R Rotameters with PVC End Fittings. Data from Schutte and Koerting.

148L Pumps for Liquefied Gases. Bull. 203-7 from Lawrence Pumps.

153R Process Equipment Fabrication. Koven Fabricators.

154L Corrosion-Resistant Vessels. Ellicott Fabricators.

155A Sealless Plastic Pumps. Catalog from Vanton Pump and Equipment.

156L Membrane-Type Filters. Croll-Reynolds Engineering Co.

157A Corrosion-Resistant Pumps and Valves. Duriron Co.

158L Roll Mills, Mixers. Charles Ross & Son.

158BR Graphite Burst Discs. Data and prices from Delanium Graphite Co.

159R Process Equipment Fabrication. Manning & Lewis.

160L Vertical Pumps. Layne & Bowler Pump Co.

161A Heat Exchangers. M. W. Kellogg.

162TL Processed Fullers Earth. Floridin Co.

162BL Tank Contents Meter. Bulls. from Uehling Instrument Co.

163R Flexible Ball Joints. Bull. 215-B from Barco Mfg. Co.

164L Rotary Blenders. Bull. 0808 from Sturtevant Mill Co.

164R Fused Quartz Products. Thermal American Fused Quartz Co.

165L Filter Medium. Palmer Filter Equipment Co.

165R Two-Stage Vacuum Pump. Bull. 95 from Beach-Russ Co.

168L Distillation Glassware. Catalog 50 from Ace Glass, Inc.

168BR Compressed Tetrafluoromethane. Matheson Co.

169BL Plastic Sheets, Rods, Tubes. Catalog from Kaufman Glass Co.

169R Temperature Measuring and Control Equipment. Claud S. Gordon Co.

170L Automatic De-Ionizer. Illinois Water Treatment Co.

170BR High-Purity Fused Quartz. Amersil Quartz Div., Engelhard Industries.

171L Centrifugal Pumps. Bull. 107 from Frederick Iron and Steel.

171R Experimental Agitator Kit. Bull. 109 from Chemineer, Inc.

172TL Grinding Equipment. Bauer Bros. Co.

172BL Spray Nozzle Catalog. Binks Mfg. Co.

173T Bulk Material Distributor. Hayes & Stolz.

173BL Bin Vibrator. Data from Bin-Dicator Co.

173BR Welded Aluminum Tanks. Brochure from R. D. Cole Mfg. Co.

174L Chemical and Petroleum Engineering Exhibition, London. F. W. Bridges & Sons.

174BR Mechanical Seals. Booklet from Durametallic Corp.

175TL Heating Grids. Details from Rempe Co.

175BL Multiple Effect Evaporator. Kutztown Foundry & Machine.

175R High Pressure Compressor. Norwalk Co.

178BL Spray Nozzle Catalog. Spraying Systems Co.

178TR Drum Warmer and Cooler. Form DW-6 from Dean Products.

179R Portable Liquid Processing Equipment. Alsop Engineering.

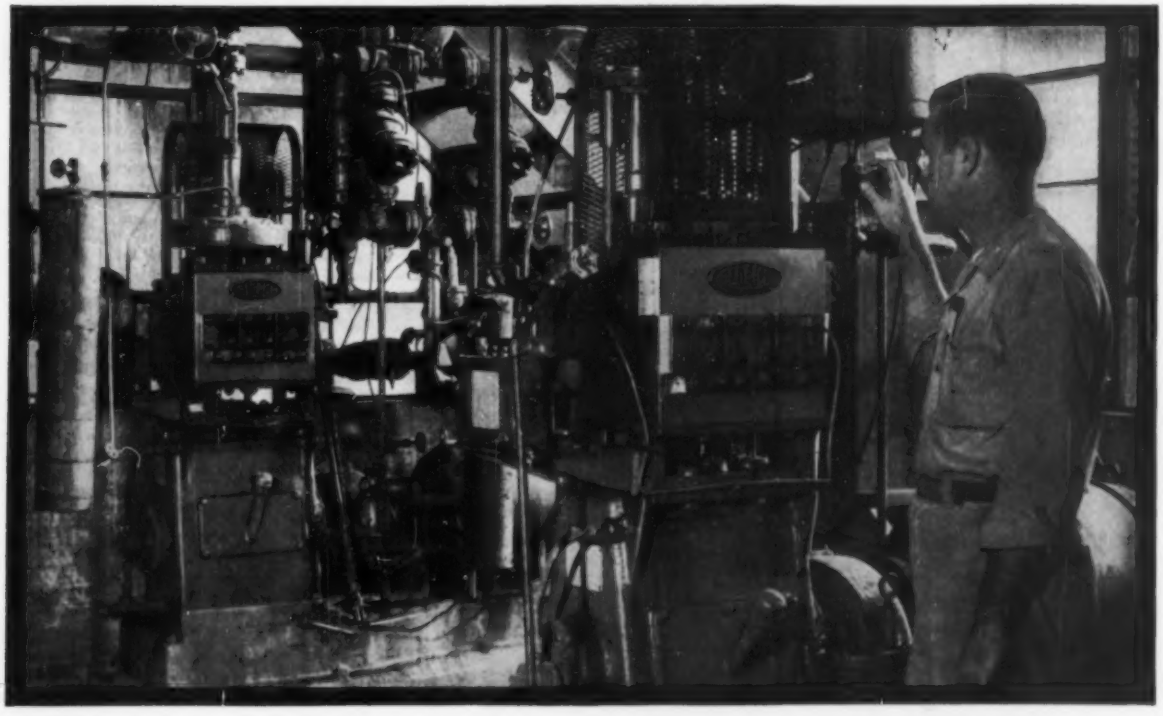
IBC Instrument Air Dryers. Bull. 857 from Milton Roy.

OBC Mixer Bulletins. Mixing Equipment Co.

EMERY INDUSTRIES LICKS TOUGH PROBLEM:

How to pump fatty acids 24 hours a day, 7 days a week, and cut maintenance costs!

Around-the-clock hydrolysis produces fatty acids from animal fats, tallow, palm, soybean, cottonseed and corn oils at Emery Industries plant in Cincinnati, Ohio. Pumps work on hot corrosive fatty materials 24 hours a day, seven days a week, and maintenance used to be a costly problem. Packings had to be replaced far too often. Valves needed frequent refacing. Wear of plungers was excessive.



How Emery solved the puzzle: Looking for an answer to the problem of excessive downtime and maintenance, Emery conferred with several pump manufacturers. Aldrich was the only company to offer a pump better in both design and materials . . . the fluid end being of stainless steel. Original, ineffective pumps were immediately replaced with Aldrich Triplex Pumps.

Result: Two Aldrich Pumps have pumped raw materials on a continuous basis since 1948. Two more were installed for additional capacity in 1954. Maintenance costs have been reduced substantially. Downtime has decreased to a minimum. Operating efficiency is now at an all-time high and quality of processing has improved. We'll be glad to send you full information on Aldrich Pumps and their advantages to you. Simply write Aldrich Pump Company, 20 Gordon Street, Allentown, Pa.

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Engineering Data

(Continued from page 108)

EQUIPMENT

301 Temperature Monitor. Suitable for monitoring or control of temperatures from —400 to +3,000° F. A compact unit ready to connect to thermocouples and source of power. Technical data from Assembly Products, Inc.

302 Horizontal Mixer Bulletin. Brochure from Young Machinery Co. describes units with capacities from a few pounds to thousands of pounds per hour. Single units in all sizes from 3½ to 500 cu. ft.

303 Instruments for Nuclear Research. Series of bulletins from Technical Associates gives details and prices of personnel monitors, scalers, rate meters, detectors, probes, accessories.

304 Steel Container Bulletin. Reynolds Aluminum Supply Co. offers data on complete line of steel containers with all types of linings for chemical products.

305 Catalog of Vibratory Materials Handling Equipment. Covers vibrators, packers and jolters, car rappers, hopper level switches, flow control valves, etc. Syntron Co.

306 Disc-Type Centrifuge. Technical data from Sharples Corp. on their DH-6 Nozljector, a continuous disc-type centrifuge with 400 gal./hr. capacity and ability to operate at pressures to 150 lb./sq.in.

307 Dust Filter Bulletin. Dimensions, specifications, illustrations of five basic "RJ" units for a wide variety of industrial dust control applications. Day Co.

308 Centrifugal Compressors for Catalytic Reforming. Built to handle wide volume range of low density hydrocarbons used in refining. Either vertically or horizontally-split casings. Bulletin from Ingersoll-Rand.

309 Sliding-Gate Temperature Control Valves. Bulletin from Jordan Industrial Sales Division of OPW Corp. contains sizing charts, dimensional drawings, control ranges, material specifications, and accessory items list.

310 Fluid Flow Rate Alarms. Bulletin from Brooks Rotameter Co. describes both magnetic or electronic types for use with rotameters to meet any flow requirement.

311 Pollution Control, Ventilation Equipment. Brochure from Claude B. Schneible Co. gives details of Multi-Wash collectors, fly ash collectors, entrainment separators, ventilation equipment.

312 Refrigeration for the Chemical Industry. Reactors, coils, compressors, condensers, controls. Brochure from Frick Co.

314 Special-Purpose Chemical Equipment. Ball and pebble mills, conical dry blenders, mixers, pressure filters. Bulletin from H. W. North Co.

315 Print-Out Recorder. Designed to monitor any production process, traffic flow, or machine operation. Totals and prints either elapsed time or number of units produced on chronologically-marked tape at predetermined intervals. Bulletin from Standard Instrument Corp.

316 Semi-Conductor Rectifiers. Bulletin from Allis-Chalmers gives technical details of germanium, silicon, and selenium rectifiers. Efficiency up to 95%. Director currents and voltage ratings shown in chart form.

317 Carbon and Graphite Equipment. Bulletin from National Carbon Co. covers shell and tube heat exchangers; cascade, concentric, and immersion type heat exchangers; centrifugal pumps; entrainment separators, many other pieces of equipment and carbon and graphite products.

318 Pneumatic Controller Bulletin. Discusses Fischer & Porter motion-balance pneumatic controllers with exclusive regenerative feedback circuit. Technical data and selection tables.

319 Ball and Pebble Mill Catalog. Operating and selection data, design and construction details, tables of engineering data. Paul O. Abbe, Inc.

320 Magnetic Flow Meter. Made by Foxboro Co. Now available for ½ in. lines as well as 1 in. For measuring flow rates as low as 3 gal./min.

321 Valve Catalog. 56-page catalog from Barksdale Valves covers complete line of "Shear-Seal" valves, graphs for calculating pressure drop, discharge and velocity of liquids, pressure conversion chart.

322 Dust Filter Catalog. Detailed information from W. W. Sly Mfg. Co. on dust control systems and how to engineer them. 36 pages.

323 Air Engineering Brochure. Describes after-coolers, air conditioners, liquid coolers, heat exchangers, condensers, refrigeration equipment. Niagara Blower Co.

324 Stainless Steel Gate Valves. Cooper Alloy Corp. offers complete line of 600 lb. stainless steel gate valves designed to meet API 600 and ASA B 16.5 specifications. Sizes ½ to 2 in. screwed and socket weld, and ½ to 8 in. flanged and butt weld. Pressure range to 1,440 lb./sq.in. Temperature range from —425 to +1,500° F.

325 Industrial pH Equipment. 8-page brochure from Beckman Process Instruments Division gives detailed descriptions and specifications of all Beckman industrial pH instruments, electrodes, and accessories.

326 Rotary Positive Displacement Pumps. Bulletin from Manton-Gaulin Mfg. Co. gives performance characteristics, graphs on operating speeds and ranges, corrosion resistance charts, data on seals.

327 Semi-Conductor Power Rectifiers. Bulletin from General Electric covers all technical aspects of their line of germanium and silicone semi-conductor power rectifiers. Many illustrations and data tables.

328 Extreme Pressure Gauge. New gauge, made by American Instrument Co., will measure pressures up to 100,000 lb./sq.in. accurately and safely. Indicator is not part of pressure system. Details from maker.

329 Low Capacity Rotary Pump. Bulletin from Eco Engineering describes the "Minilab," constructed of Hastelloy C with Teflon or carbon impellers, bearings, and Teflon packing. Specifications, flow rates, dimensional drawings.

330 Spray Type Deaerating Heater. 30-page brochure from Permutit Co. gives many case histories and flow diagrams of actual installations. Much engineering data in tabular form.

331 Process Equipment. Specially-designed equipment for mixing, size reduction and classification, bulk materials handling. 20-page bulletin from Sprout-Waldron.

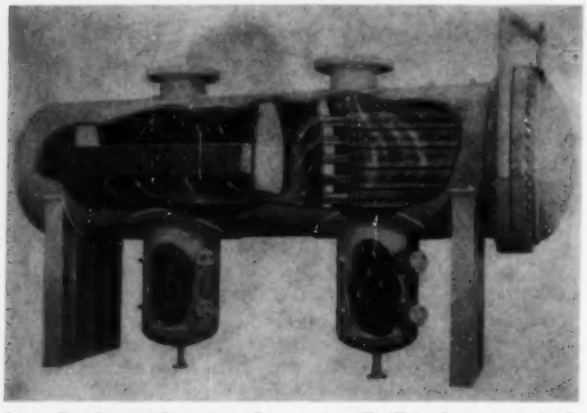
332 Processing Equipment Bulletin. 24-page brochure describes evaporators, drum, rotary, pan, and vacuum dryers, flakers and cooling drums, spray dryers, autoclaves, processing kettles, mixers, gas cleaners. Blaw-Knox, Buflovak Equipment Division.

333 Heating Coil Bulletin. Design and price information on the Dean Thermo-Panel Coil which can in many cases replace pipe coils with advantage in industrial heating and cooling processes. Dean Products, Inc.

334 Fume Scrubbers. Wet cyclone, packed tower, and special types. In solid plastic (also fiber-reinforced), rubber & plastic-lined steel, stainless steel, alloys, and lead. Bulletin from Heil Process Equipment Corp.

(Continued on page 112)

DEVELOPMENTS OF THE MONTH *(Cont.)*



395 Two-Stage Entrainment Separator. Designed to separate liquids from gas streams containing finely-divided fog or mist, the Peco-Sep separator operates as a two-stage system. The gas is first preconditioned by coalescing the liquid particles into larger droplets which are not able to "float" in the gas stream. These enlarged droplets are then removed by means of a wire mesh-type mist eliminator section. It is claimed that the unit will efficiently remove airsols and fogs from gases, as well as filtering out traces of foreign solid matter.

Typical applications include removal of traces of compressor oil from compressed gases, and the preconditioning of gas streams prior to further processing such as gas dehydration or liquefaction. For further technical details from Perry Equipment Corp. circle number 395 on Data Post Card.

ANOTHER NEW LESLIE PRODUCT

ADJUSTABLE PROPORTIONAL BAND LIQUID LEVEL CONTROL

...with adjustable level ranges up to 0-200"

Here is a new differential pressure-type liquid level control pilot that combines the wide adjustable level ranges in the table shown below with a 2-20" or 7-25" adjustable proportional band.

ADJUSTABLE LEVEL RANGE — INCHES	ADJUSTABLE PROPORTIONAL BAND (INCHES, H_2O)	CONTROL PILOT TYPE
0-40 or 0-87	2-20	LAP
0-30 or 0-91	2-20	LABP
0-200	7-25	LAUP

Maximum Static Pressure — 300 psi

One Knob — Easy Adjustment

A single knob adjustment quickly sets the proportional band where you want it, even while the system is in operation. The liquid level is maintained constantly within that band until you re-set the control pilot for new conditions.

Applications

Leslie-Level-Matic Control Pilots are used in either open or pressurized vessels to control the level of virtually any liquid including water, gasoline, oil and chemical solutions. The new control pilot is particularly useful to maintain constant levels where there are high flow rates through vessels with small cross sectional areas.

Float Cages Eliminated

There are no floats or cages needed for Leslie-Level-Matic Control Pilots, and no torque tube seals, stuffing boxes, or thermohydraulic systems. All of the primary control elements are in one place and may be installed with a fraction of the effort and cost required for displacement-type controllers.

Vibration-Proof, Dependable

All of the dependability factors for which Leslie products are so well-known are incorporated in this new control pilot, as well. Rugged, accurate, stable — it is unaffected by normal vibration or turbulence.

More Information

Send for Engineering Data Sheet describing this new Control Pilot and outlining its principle of operation.

Knob and indicator-type proportional band adjustment permits setting in a matter of seconds.

LESLIE **REGULATORS and CONTROLLERS**

LESLIE CO., 241 Grant Avenue, Lyndhurst, New Jersey

EQUIPMENT

(Continued from page 110)

335 Pneumatic Conveying and Dust Handling Systems. Fluor Products Co. offers new catalog on bulk pneumatic conveying, ash handling, dust control, and air classifying equipment, made and sold in America under license from Maschinenfabrik Hartmann A. G. of West Germany.

336 Vacuum-Insulated Helium Heat Exchanger. Can cool up to 30 lb./min. of helium down to as low as —310° F. Pressures to 5,000 lb./sq.in. Details from Hofman Laboratories, Inc.

337 High-Volume Air Sampler. For ready identification and measurement of airborne particulate matter by means of deposits on filter papers. Made of steel and aluminum, accommodates 6 x 9 in. and 8 x 10 in. filter papers. Data from Staplex Co. Bulletin.

338 Rotary Positive Gas Blowers and Pumps. Type AF blowers supplied in 18 sizes with capacities to 920 cu.ft./min. for service from 1 to 10 lb. pressure. Type XA gas pumps available in 18 sizes with capacities to 880 cu.ft./min. for pressures from 1 to 7 lb. Brochure from Roots-Connersville Blower.

339 Reversible Filtration Equipment. New system allows frequent back washing, keeps filter cakes thin, said to maintain higher filtration rates with less filteraid and lower pressure drops. Technical details from Judson G. Brown.

340 Thermometer Catalog. 56-page catalog from Minneapolis-Honeywell describes complete line of Brown rectangular case filled system thermometers, indicating, recording, and controlling types.

341 Low-Fin Graphite Heat Exchanger. New impervious graphite tube with internal low fins that more than double the inner surface of Karbate shell and tube heat exchangers has been developed by National Carbon Co. Technical data available.

342 Wood Tank Handbook. Exhaustive reference and data handbook from National Wood Tank Institute covers uses in chemical processing, design data, linings, installation information. 25 pages, many tables.

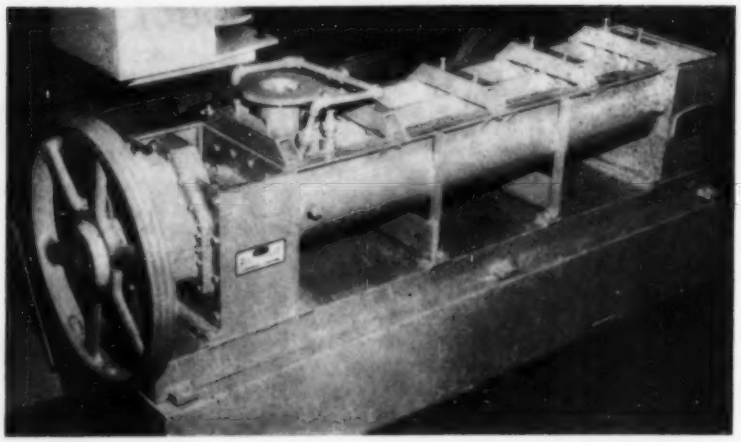
343 Large-Capacity Ball Valves. Bubble-tight performance is claimed up to 500 lb./sq.in. Round port, full bore sizes available from 2 to 24 in., with ASA, AND, or special flange configurations, in stainless steel, aluminum, or other material as required. Technical data from Vickery Co.

344 Packless Metering and Proportioning Pump. Capacity adjustable while in operation, pumping up to 2,500 lb./sq.in. Available with either Teflon-faced diaphragm or metallic bellows. Further details from Hills-McCanna Co.

345 Combustible Gas Analyzer. 8-page bulletin from Mine Safety Appliances Co. presents details of their M-S-A combustible gas analyzer Model "F". Three basic systems are illustrated.

346 Plastic Blowers and Fans. In un-plasticized rigid polyvinyl chloride for capacities from 143 to 15,000 cu.ft./min. Bulletin from Industrial Plastic Fabricators contains extensive tables on chemical resistance of polyvinyl chloride.

DEVELOPMENTS OF THE MONTH *(Cont.)*



396 Double Arm Continuous Mixer. For homogenous mixing of high density or high viscosity materials, designed for extremely heavy duty, the mixer is said to be the first of its type to provide high speed mixing at capacities of ½ to 4 cu.ft./min.

The 7-ft. machine has 7-in. mixing chambers and is built to be installed in a process pipeline. It can be equipped for vacuum operation and with temperature controlling jackets for heating and cooling. For more data from the maker, Read Standard Division, Capitol Products Corp., circle number 396 on Data Post Card.

347 Standard Polyethylene Tanks. Cylindrical, square, and rectangular. Can be supplied with mixing and stirring equipment, outlets, covers, sight glasses, and overflows. Additional data from American Agile Corp.

348 Industrial Dryers. New "Roll-Away" design said to increase drying capacity up to 25% per dryer by reducing down-time in multiple dryer operation. Folder from J. P. Devine Mfg. Co.

349 Alloy Tubing. Superior Tube Co. offers line, comprising 16 different analyses, of heat-resistant alloys which will not rupture under a stress load of 25,000 lb./sq.in. at 1,200° F. during a 1,000 hr. test period. The alloys are also oxidation and corrosion-resistant. Data from manufacturer.

350 Digital Computer Bulletin. Features full description of simplified programming for the Bendix G-15 general purpose digital computer. Also introduces new accessory that enables the G-15 to operate as a digital differential analyzer. Bendix Computer Division.

351 Engineering Data on Dall Flow Tubes. Comprehensive technical data on design, metering characteristics, flow formulas, capacity, and accuracy. Also installation information, accessory items. Many charts and graphs. Builders-Providence, Inc.

352 Pneumatic Power Actuators. Bulletin from Conoflow Corp. describes operation of the Cylinder Conomotor, listing applications including proportional control of valves, speedchangers, pumps, autotransformers, flow regulators.

353 Large-Diameter Reinforced Epoxy Pipe. Now available in 2 to 12 in. diameters, Bondstrand, product of Amercoat Corp., is made by a patented process employing interwoven fiberglass filaments, impregnated with epoxy resins and heat cured.

354 Instruction Manual on Conical Dryer-Blender. Pfaudler Co. offers instruction manual on their glassed-steel conical dryer blender. Manual covers installation, operation, and maintenance procedures. Also given are specifications and dimensions of 2, 4, 6, and 8 ft. models.

355 Industrial pH Equipment. Model 28A pH meter, made by E.I.L. Instruments, uses an "isopotential" control system to effect fully automatic temperature compensation. A stability of plus or minus 0.02 pH per 24-hr. period is claimed.

356 Eight-Pocket Rotary Feeder. Designed to feed bulk materials into process lines at pressures up to 25 lb./sq.in. Folder from Beaumont Birch Co.

357 Vertical Sump Pumps. Standard, vertically-designed rubber-lined pumps for sump and general operations. Available in 2 x 2 in., 3 x 3 in., 5 x 5 in., and 6 x 6 in. sizes with capacities from 20 to 1,400 gal./min. Data from Denver Equipment Co.

358 Sintered Metal Filtering Elements. In sintered bronze or 316 stainless steel, for pressures to 5,000 lb./sq.in. Temperature limits from—60 to 450° F. Additional information from Hoke, Inc.

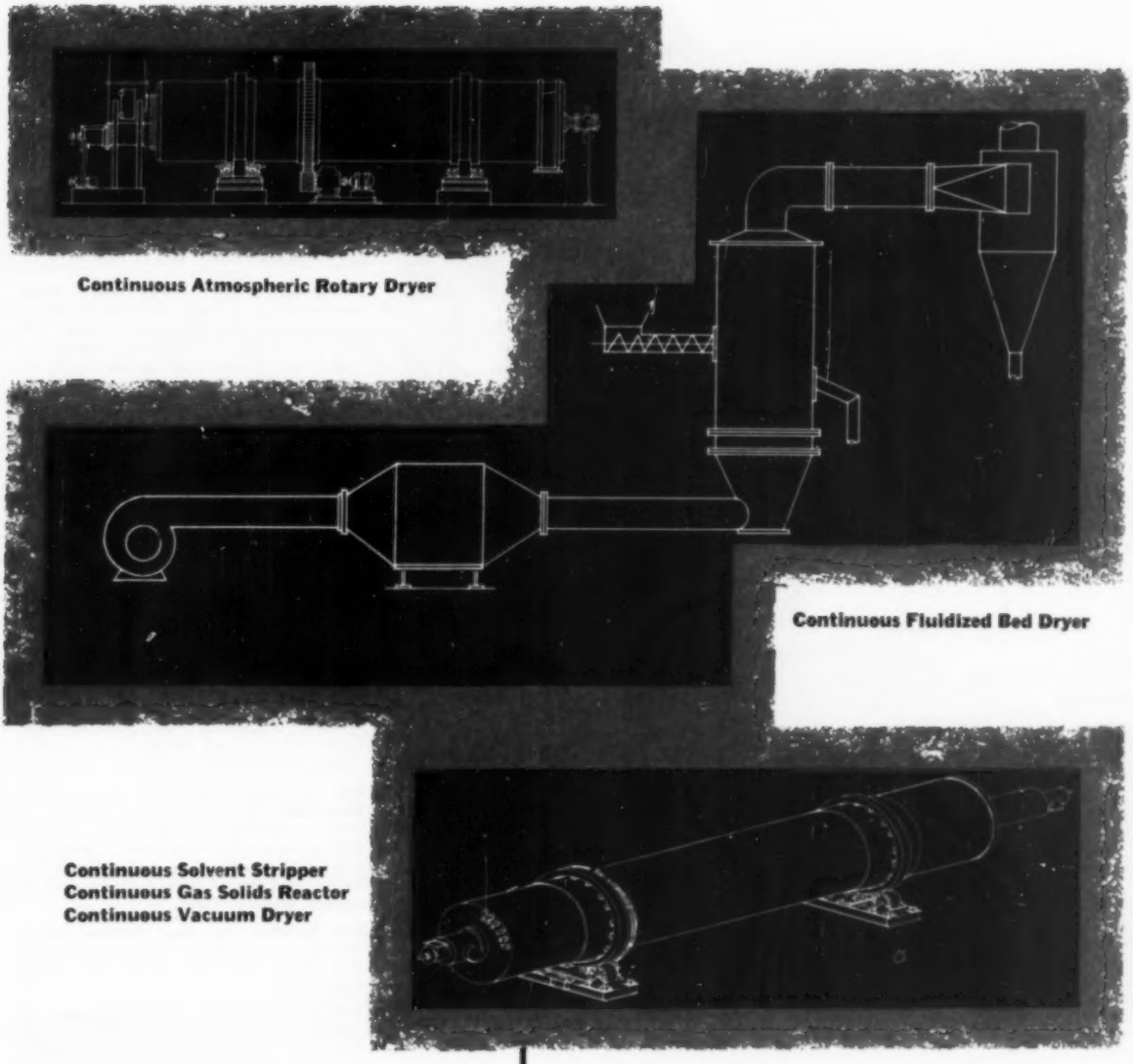
359 Cooling Tower Bulletin. J. F. Pritchard & Co. offer bulletin on their low-silhouette, "Lo-Line" cooling towers. All-steel structural members, galvanized for corrosion protection. Louvers, casing, distribution system, and fan deck of asbestos cement for fire protection. Bulletin gives complete specifications, tower dimensions, and mechanical details.

360 Pump Selector Bulletin. Describes wide variety of pump types, specially-designed for resistance to corrosion, abrasion, high temperature. Nagle Pumps, Inc.

361 Pyroceram Tubing. Corning Glass Works announces availability of tubing in diameters from ⅛ to ¾ in. in Pyroceram, new glass-based crystalline material.

362 Electric-Type Load Cells. Leeds & Northrup Co. offer technical data on electric-type load cells, claimed to have important new applications in weight measurement.

(Continued on page 114)



Continuous Atmospheric Rotary Dryer

Continuous Fluidized Bed Dryer

Continuous Solvent Stripper
Continuous Gas Solids Reactor
Continuous Vacuum Dryer

Now, at one convenient location, you can test-dry your materials in a variety of equipment

At General American's East Chicago pilot plant, you can test the drying or reacting of your materials in the widest range of drying equipment ever assembled in one place.

Louisville Dryer engineers will work with you—study your materials and needs, make recommendations for type of equipment, size and heating medium. You can check these recommendations for yourself through practical tests. Your Louisville Dryer is then engineered for most efficient and economical service—built specifically to meet your needs.

To test the drying of your materials in all these different types of drying equipment, call in a Louisville Dryer engineer. There is no cost or obligation.

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GENERAL AMERICAN TRANSPORTATION CORPORATION

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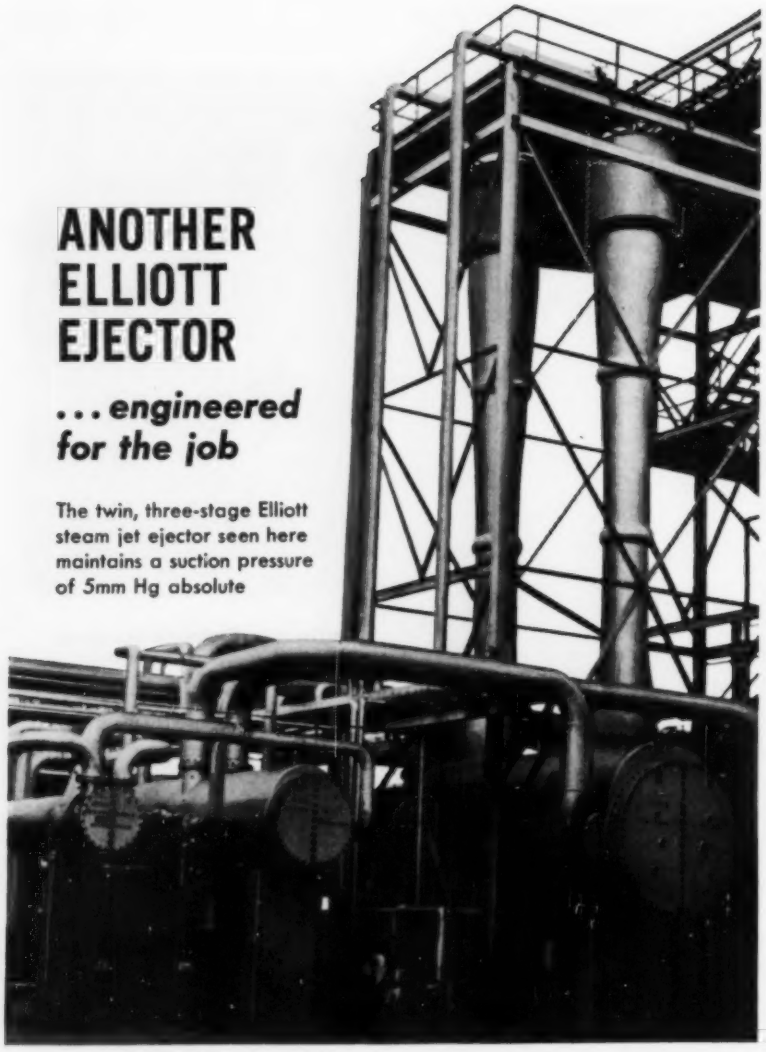
General Offices: 135 South La Salle Street, Chicago 90, Illinois.



ANOTHER ELLIOTT EJECTOR

... engineered for the job

The twin, three-stage Elliott steam jet ejector seen here maintains a suction pressure of 5mm Hg absolute

designed to serve world's largest crude oil unit

This unique, giant-sized ejector is the largest vacuum installation ever built. The design problem here was to engineer a unit which would efficiently and economically maintain the specific suction pressure required by the application. To accomplish this, Elliott engineers designed a twin-type ejector with two vertical first-stages which are 40 ft long, have 60-inch diameter inlets, and discharge to a 20,000-sq ft intercondenser. The two 20-inch second-stage ejectors discharge to a 6000-sq ft intercondenser and the third-stage ejectors discharge to a 3000-sq ft aftercondenser.

write us for descriptive bulletins

Available literature on single-stage, multistage and corrosion-resisting types illustrate Elliott's versatility in ejector design and construction for all sorts of chemical and industrial process applications. Contact your nearby Elliott District Office or write Elliott Company, Jeannette, Pa.

ELLIOTT Company

Send for complete details today

GB-2

Engineering Data

EQUIPMENT

(Continued from page 112)

363 Controlled Volume Diaphragm Pumps. A new design by Milton Roy Co. features use of Teflon diaphragms to seal the liquid ends from the plunger and housing. Capacities from 1.1 to 138 gal./hr.; pressures to 2,000 lb./sq.in. Details and specifications from Milton Roy.

364 Low-Silhouette Cooling Tower. Binks Manufacturing Co. offers technical details on a new general purpose cooling tower with a 15 to 200 gal./min. capacity. Featured is multi-finned internal decking constructed of non-corrosive plastic.

365 New Distributor Head for Graphite Absorbers. A new distributor head for falling film absorbers is constructed of impervious graphite, uses new principle to damp surges of entering liquid. Details from Falls Industries, Inc.

SERVICES

366 Corrosion Data. Blaw-Knox, Chemical Plants Division, offers reference file sheets on cathodic protection (1-12.1.12), erosion-corrosion (1-12.1.14), and concentration cell corrosion (1-12.1.15).

367 Equipment Fabrication. Alloy Fabricators specialize in the fabrication of corrosion-resistant equipment. Bulletin describing facilities and services offered to the chemical processing industries.

368 Technical Report on Gamma Ray Generation. Data on planning radiation research programs and laboratories, on designing commercial irradiation installations, and on investigating the technical and economic feasibility of high energy processing. Applied Radiation Corp.

369 Technical Data Book Catalog. Newly-revised 1958 catalog of pocket-size technical data books, selling at $1.25 each. Lefax Publishers.

370 Pressure Process for Nitric Acid. Details from Chemical and Industrial Corp on their nitric acid process. Bulletin contains process description and schematic flow sheet.

371 Nuclear Engineering Services Brochure. Describes experience of Burns and Roe, Inc. in nuclear power generation and reactor facilities, environmental testing, aviation test facilities, and materials manufacturing, processing, and handling.

372 Equipment Fabrication Services. Bulletin from Artisan Industries gives details of the engineering and fabricating services

(Continued on page 116)

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▶ **GET** *up-to-the-minute catalogs, data sheets and bulletins on new chemical products, processes and equipment.*

TOWER PACKING

All the facts about HARSHAW *tellerettes*

Contained in this comprehensive booklet discussing the application of Harshaw Tellerettes to tower packing.

Subjects discussed at length (accompanied by pertinent charts)

1. The Tellerette Shape
2. Physical Characteristics
3. Lower Capital Investment and Operating Cost
4. Low Weight
5. Reduced Tower Height
6. Increased Tower Capacity
7. Support Plates
8. Corrosion Resistance
9. No Clogging

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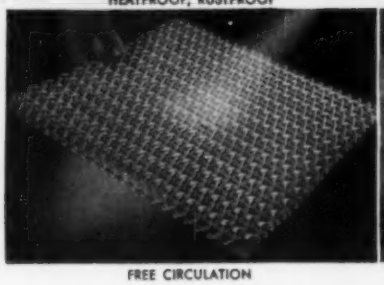
Cambridge WOVEN WIRE BELTS

HEATPROOF, RUSTPROOF

FLASH DRAINAGE



FREE CIRCULATION

NO SEAMS OR LACERS

METAL-MESH BELTS GIVE FAST, UNIFORM PROCESSING AT LESS COST

Whether you process slab, sheet or pelletized materials through wet, dry, hot or cold operations, Cambridge belts can combine movement with processing to give you increased production, and higher product uniformity at lower operating costs. Here's how:

CONTINUOUSLY MOVING BELTS ELIMINATE BATCH PROCESSING—give faster, less costly production; reduce slow, costly manual handling.

OPEN MESH PROVIDES FREE AIR, LIQUID CIRCULATION—atmospheres and solutions circulate through the belt and around product for fast, uniform processing, flash drainage. Close mesh can't mar or mark soft slab or sheet products.

ALL-METAL CONSTRUCTION IS HEATPROOF, COLDPROOF, RUSTPROOF—Cambridge Belts can be woven from any metal or alloy to take up to 2100° F. or sub-zero temperatures, yet remain impervious to attack from water, acids or caustic solutions.

SPECIAL SURFACE ATTACHMENTS AVAILABLE—raised edges and cross flights to keep product on belt during movement.

Currently, Cambridge Belts are used in the chemical industry for such diversified operations as bagging cement, drying wool, cooling and drying polyethylene sheets, washing, rinsing and drying catalysts, tanning hides, drying coal, and processing rubber.

Talk to your Cambridge Field Engineer soon. He'll recommend the belt size, mesh or weave—in the metal or alloy best suited to your operations. You'll find his name in the classified phone book under "BELTING-MECHANICAL". Or, write for FREE 130-PAGE REFERENCE MANUAL giving mesh specifications, design information and metallurgical data.

The Cambridge Wire Cloth Co.

WIRE CLOTH | METAL-MESH CONVEYOR BELTS | WIRE CLOTH FABRICATIONS

Department 1, Cambridge 3, Maryland

OFFICES IN PRINCIPAL INDUSTRIAL CITIES

Engineering Data

(Continued from page 114)

DEVELOPMENTS OF THE MONTH (Cont.)

397 Single-Unit Hot Gas Washer. The new Lehigh Dynamic hot gas washer is a compact unit less than 15 ft. high, designed for melting furnaces, chemical processes, or other conditions where hot air or gases present a dust pollution problem. It will resist temperatures up to 2,000° F.

The unit is available with manual or automatic sludge removal. For economy where the dust load is light, smaller units are equipped with a recirculating water pump, water level float, and complete piping. Capacity range is dependent on use. Other features include large access doors which simplify interior inspection and maintenance, and easy push-button operation. For additional technical details from the manufacturer, Lehigh Fan & Blower Division, Fuller Co., circle number 397 on Data Post Card.

○ **CIRCLE** *your Data Service requests on the handy postcard on page 106 to*

▶ **GET** *up-to-the-minute catalogs, data sheets and bulletins on new chemical products, processes and equipment.*

offered by its five component companies, Artisan Metal Products, Jet-Vac Corp., Kontro Co., Metal Fabricators Corp., Hi-Speed Equipment Co.

MATERIALS

373 Packing Handbook. Contains detailed table listing effect of numerous gases, liquids, and solvents on packing materials from metals to synthetics to leather. Garlock Packing Co.

374 Silicone Catalog. 16-page catalog from Dow Corning describes over 150 silicone products. Detailed charts, tables, graphs, and data on properties and performance. Cross-indexed for ready reference.

375 Two New Diepoxides. Technical information is offered by Becco Chemical Division, Food Machinery and Chemical Corp., on dicyclopentadiene dioxide and limonene dioxide. Research quantities also available.

376 Chlorinated P-Xylene Derivatives. Series of six data sheets from Diamond Alkali list physical properties, solubilities, toxicity, and reactions.

377 Polyether Flexible Foam Data. Allied Chemical & Dye offers technical bulletin with 6 pages of new fundamental data on formulation, preparation, and curing of polyether flexible foams.

(Continued on page 118)

from the first large-scale $NaBH_4$ *plant comes a basic ingredient for*

ZIP FUELS

Badger constructs new Metal Hydrides plant from site clearance to start-up. This new plant is among the first to produce $NaBH_4$, an important ingredient of "exotic fuels" for trans-sonic devices, on a large scale. From site clearance to initial start-up, Badger handled the complete equipment engineering and construction for the project.

While the characteristics of sodium borohydride make it fine for high performance fuels, its production creates real problems in equipment and plant design. How well did Badger meet and solve these problems?

Officials and engineers at Metal Hydrides have said they were impressed by the proven ability of Badger personnel and by the intelligent approach that was brought to MHI's problem. In addition, Badger was complimented for its willingness to undertake the project on a "crash" schedule. Metal Hydrides' judgment proved sound when Badger delivered the plant on schedule in spite of delays due to the steel strike.

Each year more and more leading firms with unusual and pioneering engineering projects choose Badger. The ability and experience that lead so many to the same choice can pay off on your projects, too. Why not inquire?

The Badger Key Man

FROM INITIAL NEGOTIATIONS TO "ON STREAM" YOU DEAL WITH A BADGER PRINCIPAL. *Badger Engineering Projects are group efforts headed by a Key Man. More than just a sales engineer, he is always a Badger principal — always the Key Man in the execution of the project.*

By channeling project liaison, coordination and administration through a widely experienced company principal, you find many policy level decisions can be made on the spot. Investigate what Key Man Policy can mean to the projects you are planning.

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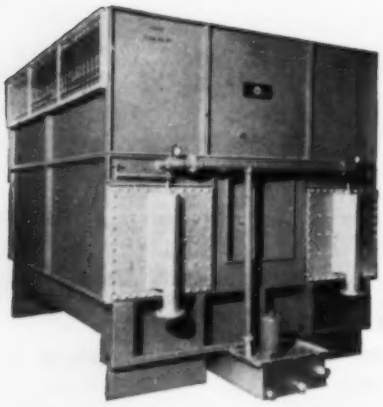
Aerial view of Metal Hydrides' new Sodium Borohydride Plant at Danvers, Massachusetts, as it looked while under construction. The plant process involved the preparation of sodium borohydride using sodium and boric acid as raw materials.



Is your plant CRITICALLY SHORT of WATER?

● You will make major water savings, reduce your costs, solve your problems of water supply or disposal and get HIGH OPERATIONAL EFFICIENCY with Niagara "Areo" Evaporative Heat Exchangers, After Coolers or Condensers for these important plant services or processes:

- **AFTER COOLING and air drying for large air and gas compressors and AIR LIQUEFACTION**
- **COOLING ENGINES, COMPRESSORS, HYDRAULIC PRESSES**
- **COOLING QUENCH BATHS, FURNACES, INERT ATMOSPHERES**
- **COOLING ROLLS, WELDERS, DRAWING OR EXTRUSION DIES**
- **PRODUCT AND PROCESS COOLING CHEMICALS OR INTERMEDIATES**
- **COOLING LIQUIDS OR GASES IN CLOSED SYSTEMS**
- **VAPOR CONDENSING UNDER VACUUM**
- **ELECTRONIC PROCESS COOLING**

High operational efficiency means: precise temperature for improved product and process quality control, heat removal at rate of input, simple operating conditions, real economy in upkeep, sustained full capacity.

Also it means cooling in a closed system with your product kept free from contamination or, when condensing, getting a pure condensate holding high quality in your product or material.

Niagara machines do the work of a cooling tower plus shell-and-tube coolers with a single machine that saves piping, water handling disposal and treatment expense and 95% of water consumed by contact cooling methods.

Write for Bulletin 129, 130, 132, 136R.

NIAGARA BLOWER COMPANY

Over 35 years of Service in Industrial Air Engineering

Dept. EP-2, 405 Lexington Ave., New York 17, N. Y.

District Engineers in Principal Cities of U. S. and Canada

(Continued from page 116)

DEVELOPMENTS OF THE MONTH (Cont.)

398 New Type Acetylene Generator. Linde Co. announces the Oxweld MP-11 acetylene generator equipped with a newly-developed automatic signal system. With a carbide capacity of 500 pounds, the MP-11 will produce 1,000 cu.ft. of medium-pressure acetylene per hour. Over shorter intermittent operation periods, 2,000 cu.ft./hr. are obtainable.

The automatic signal system consists of a howler and indicator lights that provide both audible and visual warning if minimum carbide supply, water level, or water temperature deviate from normal.

The unit, with standard regulating equipment, can also be used to supply low-pressure acetylene to a piping system. One MP-11 in continuous operation can replace a multiple installation of smaller capacity generators.

Safety factors are outstanding. Each generator is equipped with an automatic carbide and water shutoff system, a hydraulic back-pressure valve, and pressure relief valves. For more technical data, circle number 398 on Data Post Card.

MATERIALS

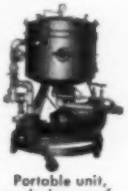
378 Chemicals for Research. 40-page booklet from Dow Chemical lists about 160 chemicals available in sample quantities for research purposes. Each listing includes formula, physical description, typical properties, and sample size available.

379 Technical Data Chart on Waxes. Physical properties of 37 natural and synthetic waxes tabulated in chart form. Melting and congealing points, densities at various temperatures, penetration values, and viscosities. Baker Castor Oil Co.

380 Plastics Data. Application and physical property data on resin-rubber blends, polyester resins, vinyl resins. 8-page booklet

(Continued on page 120)

Portable filter with slurry tank and feeder.


Portable unit, explosion proof.

Portable unit corrosion proofed, rubber lined with plastic plates.

Portable filter for polishing operations.

Low cost Vacuum Filter.

The most complete line of filtration equipment- engineered to meet the requirements of hundreds of products

By concentrating on filtration engineering and manufacturing exclusively for over 30 years, Sparkler is able to offer a solution to practically all filtration problems without expensive experimentation.

Standard filter models available for:

Chemicals	Electroplating	Varnish
Pharmaceuticals	Petro Chemicals	and Lacquers
Beer,	Petroleum Derivatives	Hydraulic Oil
Whiskey, Wines	Food Products	Steam Condensate

and many other products in addition to large volume water filtration for municipal and plant use. Personal service on all filter installations.

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c/o Serapis s.r.l.
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GET TOP PRODUCTIVITY FROM MINIMUM POWER CONSUMPTION

. . . with NETTCO Engineered Agitation!

ELIMINATE UNSATISFACTORY AGITATION, high power costs, and excessive maintenance with Nettco "process-rated" agitators. Standardized components (motor, drive, shaft, stirrer) can be combined to meet your exact size, speed, HP, and other process specifications. Check these Model T features . . .

- **Minimum moving parts in compact, fully enclosed housing**
- **Interchangeable ratios from 6.25:1 to 100:1**
- **Dust, fume, and moisture-proof**
- **Complete range of speeds**
- **Anti-friction bearings throughout, quiet operation**
- **Splash lubrication — oil trapped against leakage**
- **Large diameter "stepped" vertical shaft**
- **Widely spaced, oversized Timken bearings**

Model WT units (worm gear reduction drives) offer ratios from 3.5:1 to 68:1 and can also be "processed-rated" to your specifications for greater savings and dependable, uninterrupted service. Ask Nettco agitation engineers for recommendations. Request Bulletin 551 and data sheet from **New England Tank & Tower Company, 92 Tileston Street, Everett 49, Mass.**

NETTCO
ENGINEERED AGITATION

FREE LITERATURE

Please send me the following literature:

☐ **Tank Top Agitators—Bulletin 551**
☐ **Portable & Tripod Mixers—Spec. Sheets**
☐ **Pipeline-Flomix®—Bulletin 531**
☐ **Side Entering—Bulletin 532**

Engineering Data

MATERIALS

(Continued from page 118)

from Naugatuck Chemical Division, United States Rubber Co.

381 Buyers Guide to Solvents and Chemicals. Eight-page technical brochure gives formulas and test results on alcohols, esters, glycols, ketones, chlorinated solvents, plasticizers, and miscellaneous solvents. American Mineral Spirits Co.

382 Studies on Butyl Rubber Curing. Thiokol Chemical Corporation offers two new studies on dimethylol phenol resins as vulcanizing agents for Butyl rubber. Tables show results with organic and inorganic halide accelerators, effect of other additives on cure rates, compression set, heat resistance, and physical properties.

383 Sprayed Ceramic Coatings. Hard, inert ceramic coatings are highly resistant to corrosion, abrasion, and erosion, provide excellent thermal shock resistance at temperatures to 3,700° F. Data from Chemical & Power Products, Inc.

384 Booklet on Pyrazines Chemistry. A survey of significant recent literature in the field. Application information on preparation of pharmaceutical products, high polymers, insecticides, and dyes from the pyrazines. Wyandotte Chemicals Corp.

385 Thermocouple Extension Wire. Revised catalog from Thermo Electric Co. gives charts on calibration symbols and wire color codes, wire resistance, weights and electrical properties, and insulation characteristics.

386 Data on Radioisotopes. Atomic Energy of Canada offers two booklets: "Radioisotopes —What They Are and How They Are Produced"; and "Decay Tables for Radioactive Isotopes."

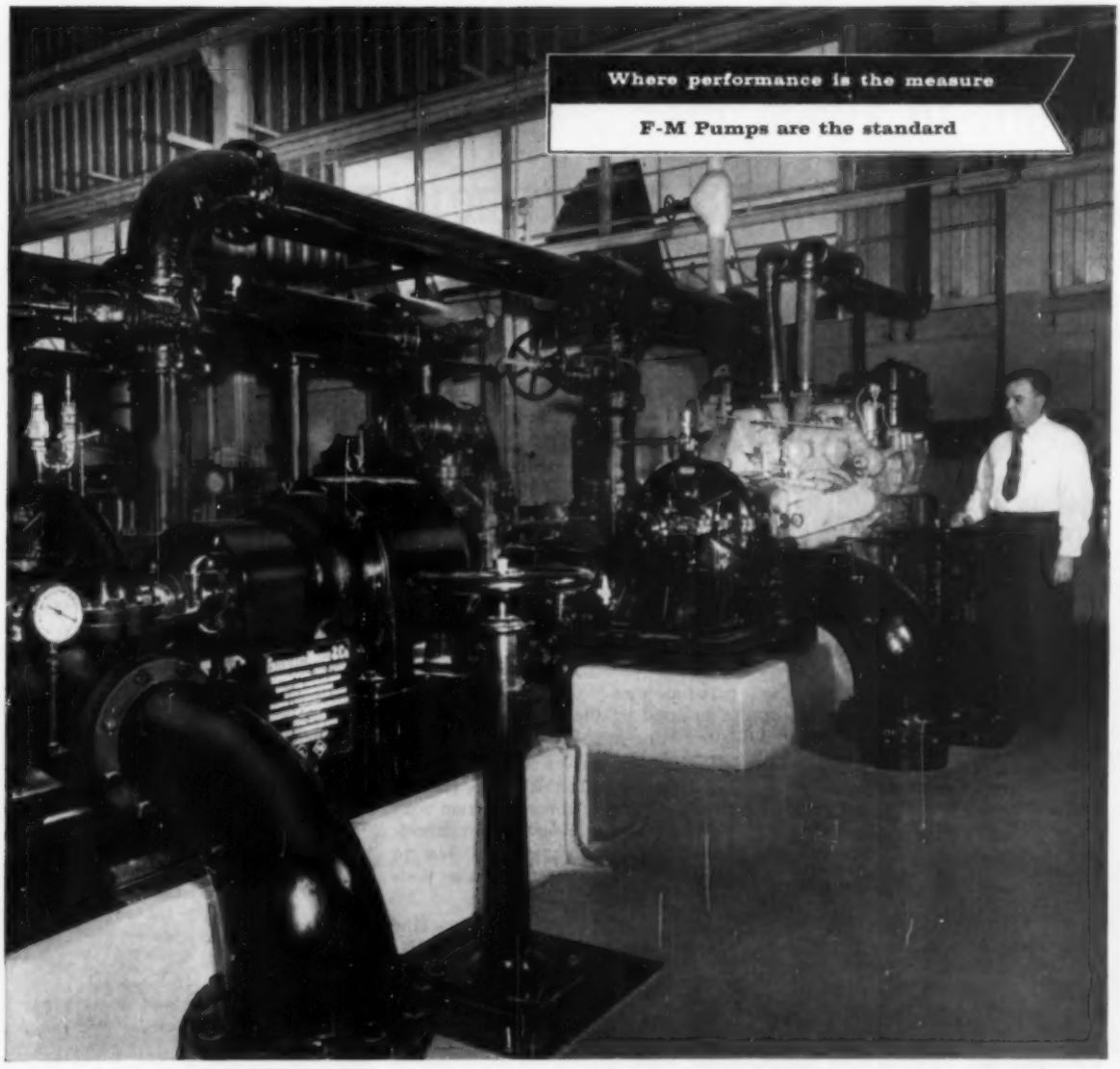
387 Phenolic Products Catalog. Brochure from General Electric describes their complete line of phenolic resins, varnishes, and molding powders.

388 Resins for the Paint Industry. Colton Chemical Co. offers their Handbook for the Paint Industry with all technical bulletins, and chart showing properties and suggested uses of Flexbond and Vinac emulsions.

389 Booklet on Polyethylene Glycols. 54-page booklet gives properties, applications, storage, specifications, and testing information on polyethylene glycols. Special table gives solubilities in common solvents and compatibilities with common ingredients of formulated products. Union Carbide Chemicals Co.

○ **CIRCLE** *your Data Service requests on the handy postcard on page 106 to*

▶ **GET** *up-to-the-minute catalogs, data sheets and bulletins on new chemical products, processes and equipment.*



Mr. George Biggar, plant engineer of Ford Motor Company assembly plant at Mahwah, N. J., checks Fairbanks-Morse fire pumps (1500 gpm. motor-driven pump in foreground, 2500 gpm. diesel-driven pump near Mr. Biggar).

Ford guards against fire at giant new plant

To protect one of the world's largest auto assembly plants against fire, Ford Motor Company depends on these two Fairbanks-Morse fire pumps. As the heart of an extensive system, the two F-M pumps provide defense in depth, one pump backstopping the other.

This installation is typical of the great care and planning by modern industry to prevent the catastrophe of fire. Call in your F-M Sales Engineer for expert assistance in pump specification. As builder of the world's greatest variety of hydraulic combinations, Fairbanks-Morse will provide the exact type, exact size pump you need for maximum dependability.

For information write Fairbanks, Morse & Co., Dept. CEP-3, 600 S. Michigan Ave., Chicago 5, Ill.

Ask for F-M Fire Pump Bulletins 5814F (horizontal) and 6920F (vertical).

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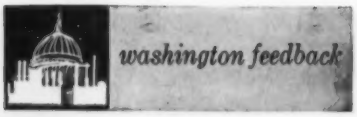


Joseph L. Gillman, Jr.

Postal $$$ to Chemical Industry?

Proposed bill to raise postal rates includes provision for $175 million a yr. for new equipment.

A bill endorsed by President Eisenhower will raise postage rates for out-of-town mail to five cents for the first ounce, local mail to four cents, and second-class mail (magazines, etc.) incrementally to a maximum of 30%. The bill has already been passed by the Senate, and Washington observers believe it has some chance of becoming law despite stiff opposition.

Of particular importance to the chemical industries—who are increasingly seeking new markets for their products—is a provision in this bill for apportioning a part of the proceeds for chemical industry products.

Increased revenue from first class mail—expected to total $175 million per year—would be used for modernization of postal facilities, for new equipment, and for improved processes.

Much of the money, for a while at least, will probably be spent for modernization of mail handling techniques at major metropolitan-area post offices. New York City, for example, which has annual postal receipts of $275 million, reportedly requires a modernization job running close to $100 million; Chicago needs about $40 million; other cities, proportional sums.

How is such modernization to be carried out? One way will be through the use of automatic mail-handling equipment. To illustrate the meaning of modernization, consider how the post offices operate now: In the first place, 80% of most cities' mail arrives at the post offices after five o'clock. This calls for thousands of short-shift workers. (In many cases these are part-time men.) Three-fourths of the labor used by the postal system goes into sorting and distributing mail.

When mail arrives at a post office, it has to be faced; this means turning all letters to face in one direction with the stamp on the lower side for cancellation. Next comes sorting, first to large-area targets, then to smaller divisions—county, city, zone.

One important job for the machine of the future is *facing*; several solutions are under experiment. The British are using a special coating on their stamps. Our most successful method so far uses optical detection of color wave lengths. If the letter or package doesn't reflect the right light, machines turn it over until it does—and, presumably, there's the address.

After the destinations are read (a man-power job), letters and packages are pigeonholed or thrown into bags—in all but three post offices. In Silver Spring, Md., men at keyboards effect the sorting of mail mechanically. Another conveyor system is under test in Detroit. In Baltimore, a keyboard system sorts parcel-post packages rapidly. The Bureau of Standards is currently developing a sorting system for letters. Based on the code-marking of each envelope by a manually-operated keyboard, the system permits automatic sorting. A model is now under construction. Each of these machines may be the forerunner of devices expected to be installed under the new program.

The Post Office Department has a Research & Engineering Division which, in 1950, had a budget of $¼ million; by last year, this had risen to $4,314,000. From this group of technologists—who have access to industrial laboratories—have come a number of developments important to the chemical industry; more may well be on the way.

For example, a plastic letter tray of rigid acrylonitrile butadiene copolymer will probably be the subject of specification in the near future; these will be bought by the hundreds of thousands.

Pressure-sensitive adhesive bands for use in business offices are being used to bind outgoing mail, grouped by delivery points. Millions of feet of such tape, supplied by the Post Office, are now in use.

About 19,000 bags of overseas mail leave our shores every week. The bags are returned empty. Cost per round trip for the bag alone is 30¢. Solution: use of reinforced, water-repellent bags. A short time ago, it appeared that a suitable bag for this job would have to be made in five layers. Now, a single-wall, glass fiber-reinforced bag does the job better. Sewn closed, the bag makes a one-way trip. But because all problems of bursting and snagging are not yet solved, registered mail still goes in the conventional bags, nearly all of which are today made of nylon.

By whatever means the modernization is brought about, it looks like it will be with us shortly, and that it will create a prodigious demand for products of the chemical industry.

Inco high-temperature research note:

Effect on heat resistant alloys of the combustion products of Bunker "C" fuel oil

The use of Bunker "C" and other types of residual fuel oils for industrial heating poses a severe high temperature corrosion problem.

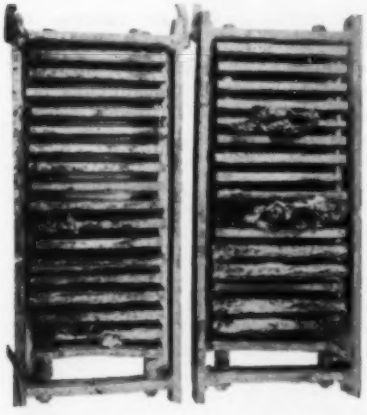
Combustion products from these fuels include a considerable amount of ash containing vanadium pentoxide, sodium and sulfur compounds, which have a low fusion temperature.

When this ash is liquid, it creates a fluxing action on the metals and high corrosion rates follow.

Since long field experience has shown all of the heat resistant alloy to be susceptible to this type of damage, an approach based on the addition of substances to the fuel oil to prevent the ash from becoming molten has been adopted.

Inco High Temperature Engineering Service conducts in-plant tests

Inco engineers—in cooperation with several Steam Power and Stationary Gas Turbine companies have conducted a series of in-plant tests in order to determine the behavior of certain high temperature alloys when exposed to Bunker "C" burned with or without additives.



Test racks after exposure

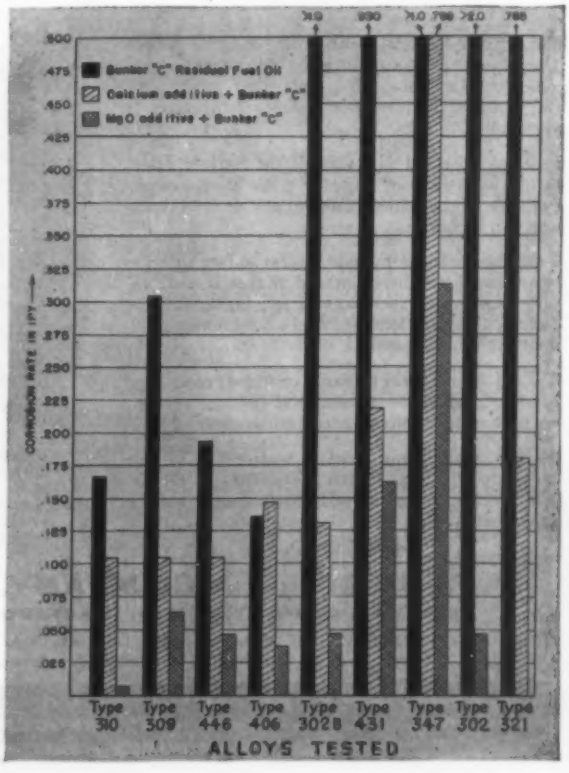
Each rack carried many specimens of different compositions, all precisely measured before installation. Corrosion rates are developed from these specimens by metallographic examination.

Corrosion results were obtained on both cast and wrought alloys as well as on some alloys with various coatings. The bar graph (below) shows the results of nine of the alloys tested. (Note for example, the performance of type 310 under the severe vanadium, sodium and sulfur environment.)

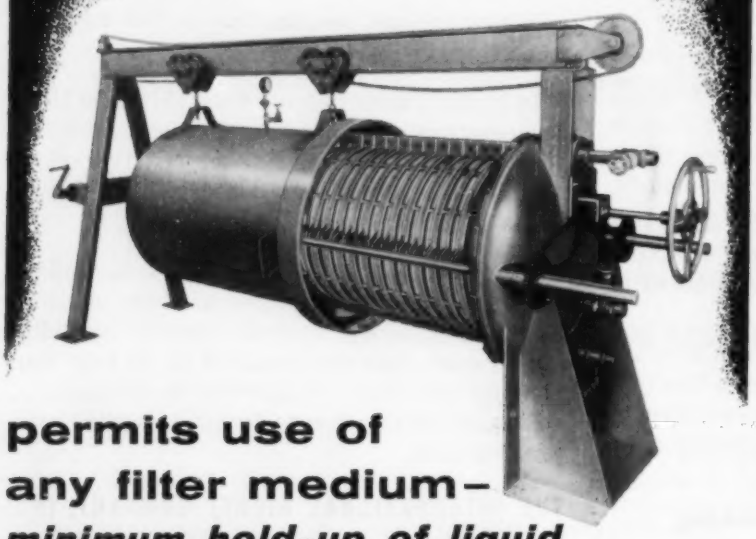
In general, data derived from this Inco High Temperature test points up the benefits of using additives when burning Bunker "C" fuel oil. It also provides a basis for material selection in terms of cost and length of service.

Inco has investigated many metals and alloys under hundreds of high temperature environments. If you have a metal problem involving high temperature performance let us help you. Send for our High Temperature Work Sheet . . . a form that makes it easy for you to outline your problem to us.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N. Y.



NEW VERTICAL LEAF FILTER



permits use of any filter medium—
minimum hold-up of liquid
no danger of overloading

The Shriver Vertical Leaf Filter—a new concept in enclosed, pressure filtration equipment—overcomes the limitation on usable filter media and eliminates difficulties in cleaning, if the filter is overloaded.

1—When operated with frames, the Shriver Filter can be used with any paper or other filter medium available in sheet form. Cake of any desired thickness can be built up.

2—When used as a precoat filter, the fact that the leaves can be easily separated, makes it unnecessary to provide excessive leaf spacing to prevent damage from overloading. There is minimum hold-up of unfiltered material.

3—Leaf spacing may be easily changed; ready conversion from top to bottom feed (or vice versa); no pipe connections to break when cleaning.

4—Now available in steel or stainless steel construction for total filtering area to 500 sq. ft., for filtering pressures to 80 psi. Larger sizes to specifications.

Leaves with filter paper; frames can be of any desired thickness for cake recovery.

Leaf arrangement for precoat filtration; leaf spacing may be reduced to minimum.

Inquiries invited

T. SHRIVER & COMPANY, INC.

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SALES REPRESENTATIVES IN: Decatur, Ga.—Houston, Tex.—Livonia, Mich.—St. Louis, Mo. San Francisco, Cal.—Montreal, Que.—Toronto, Ont.

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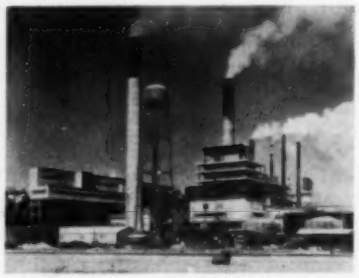
HORIZONTAL PLATE FILTERS • CONTINUOUS THICKENERS
SLAB FORMERS • DIAPHRAGM PUMPS • ELECTROLYTIC CELLS

INDUSTRIAL NEWS

A new unit, now under construction, for the production of ammonium perchlorate for solid propellent use marks Pennsalt Chemicals' entry into another phase of the missile fuel field. (The company is already deeply involved in production of elemental fluorine and high energy fluorine chemicals). Pennsalt's initial perchlorate unit will be adjacent to its sodium chlorate plant at Portland, Oregon, plans are in the works for another larger unit at a yet unannounced location in the South. □



A new 100,000 ton wood pulping plant, representing an investment of some $25 million, reflects confidence in the future of the industry. Shown is the new Jessup, Georgia, unit of Rayonier, now on stream. The plant, a "mirror image" of Rayonier's existing mill on the site, brings the company's total annual capacity for eight plants to 915,000 tons.

Underground storage caverns to hold more than 28 million gallons of liquefied petroleum gas are nearing completion at Standard Oil's Bayway, N.J., Refinery. Mined at a minimum depth of three hundred feet below the surface, the underground network will eventually include 6,000 linear feet of tunnels, most of which are 13 feet wide and 22 feet high. The first cavern, for 300,000 barrels of propane, has been virtually completed; the second, for 375 barrels of butane, is scheduled for the near future. Both should be in operation by late 1958. □

A contract to design, engineer, and construct a 150 million cu. ft./day gas processing facility has been given to The Fluor Corp. The new unit will be jointly owned by Texas Natural Gasoline Corp. and Tennessee Gas Transmission Co. Amount of contract is $3 million plus. Engineering work has already begun, plant will be located 15 miles southeast of New Orleans, will extract propane from natural gas feed. □

This Girdler hydrogen plant is part of the catalytic reformer installation of American Gilsonite Co., built by H. K. Ferguson Co.

Girdler hydrogen plant helps convert ore into high octane gasoline

The first commercial plant to make gasoline from a raw material other than crude oil is the refinery of American Gilsonite Company at Gilsonite, Colorado. Here a solid hydrocarbon, Gilsonite* ore, is processed into high octane gasoline.

A Girdler hydrogen plant, shown at left, is a key part of the catalytic reforming. Its hydrogen, generated from propane and butane, is used to purify the gasoline produced.

Girdler has built much of America's hydrogen plant capacity installed during the past ten years... also many other types of process plants. Take advantage of Girdler's proven experience as engineer-constructors when you plan modernization or expansion of processing facilities.

* Gilsonite is a Registered Trademark.

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Stainless Steel 317L

ALLOY VAPORIZERS

38" × 10' Vertical Vaporizer, process in tubes, dowtherm in shell. Process side is all 317 ELC Stainless steel, shell side is carbon steel. This is 1 of 12 built for two chemical processing plants.

We Build

CORROSION RESISTANT VAPORIZERS

We have the experience in building Vaporizers and are familiar with the alloy best for your particular purpose, including:

Stainless Steel 317 L

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Inconel

3½% Nickel Steel

Our facilities include X-Ray and impact testing.

Our engineering-design division will welcome the opportunity of solving your Alloy Vaporizer Problems.

RICHARD M. ARMSTRONG CO.
BOX 566
WEST CHESTER PENNA.

INDUSTRIAL NEWS

Workers connect lengths of what is said to be the longest lastic pipeline ever used for corrosive chemical service. The line, fabricated of high-pressure polyethylene, links the zirconium and titanium sponge plant of Mallory-Sharon Metals and the sodium plant of U. S. Industrial Chemicals at Ashtabula, Ohio. The record-breaking line is 6,200 feet long, is fabricated in 30-ft. sections weighing 120 lb. each, will be used to transport a saturated brine solution.

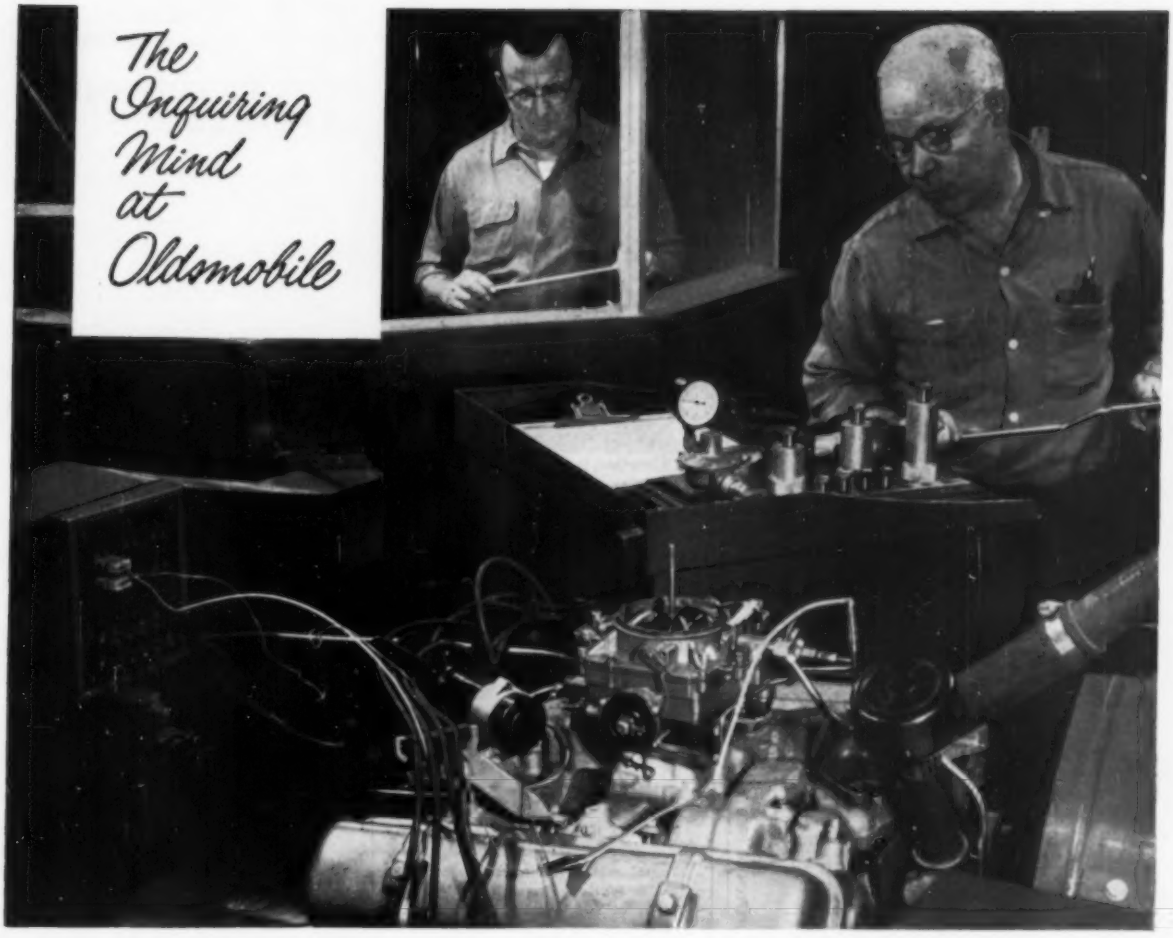
Olin Mathieson Chemical and Cuno Engineering have announced formation of a jointly-owned company, Olin Cuno Filter Corp., for the manufacture and sale of Micro-Kleen filters abroad. The action follows intensive surveys of the European market for this type of industrial filter. □

Production of heavy denier nylon for use in tire cord and other industrial products is underway at DuPont's new facilities at Richmond, Va. Capacity of this, DuPont's fourth nylon plant, is 40 million lb./yr. of fiber. □

A design and construction contract for a $1.5 million chemical process plant has been awarded by Merck to Wigton-Abbott of Plainfield, N. J. The unit will form part of Merck's new Danville, Pa., facilities for expanded production of ultra-pure silicone for the electronics industries. □

Difficult separation problems will be the specialty of a new laboratory established by Centrico, Inc. at Englewood, N. J. According to Centrico, all liquid separation techniques can be handled, including liquid-liquid separation, liquid-liquid mixing, liquid-liquid extraction, clarification, and concentration.

The Inquiring Mind at Oldsmobile



no. 2 OF A SERIES

IT "WORKS" WHILE IT WHISTLES

Advanced sonic testing techniques are used to make precision measurements that determine an engine's compression ratio.

To Olds engineers, compression ratio is a direct measure of the engine's thermodynamic efficiency; the higher the compression ratio, the more energy utilized from the fuel. But with higher compression ratios, engineers needed to know whether cylinder heads and combustion chambers were accurate during initial engine development. To meet this challenge, Oldsmobile engineers and General Motors Research developed a simple, yet extremely accurate measuring device commonly called the "whistle checker".

Based on the principle of resonance, the known volume of air in the "whistle checker" is placed in resonance with the unknown volume of air in the combustion chamber. A reading of the micrometer adjusting screw of the "whistle checker" is easily translated into cubic centimeters and is accurate to .2 cc. What is just as important, this instrument can tell if there is any loss of compression due to leakage past the piston rings.

In many ways and in many directions the Inquiring Mind at Oldsmobile is constantly probing, constantly seeking new and better ways to build the finest automobiles in the industry. Try a '58 Oldsmobile on the road. You'll discover the difference for yourself.

OLDSMOBILE DIVISION, GENERAL MOTORS CORP.

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Pioneer in Progressive Engineering ...Famous for Quality Manufacturing

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REGISTERED U. S. PATENT OFFICE

A JOURNAL OF USEFUL INFORMATION FOR THE SOLUTION OF CORROSION PROBLEMS

IMMERSION HEATER USES ACIDPROOF TANTALUM SHEATH

The combination of tantalum, Teflon* and a high watts density Firerod** cartridge provides an acidproof heater that proves ideal for a variety of chemical processing jobs where hot acids must be used.

High Heating Efficiency, Acidproof Construction

The electric immersion heater shown here consists of lead wires passing through a Teflon-covered copper tube and a 2000-watt, 230-volt Watlow heating element sheathed by a 6⅜" tantalum tube. Teflon and tantalum are swaged together to make a leakproof connection. The cartridge itself features a design which provides a low temperature differential between the resistance wire and the tantalum sheath. It will heat one gallon of tap water from 8°C to 96°C in 15 minutes. A gallon of 62% H_2SO_4 solution can be heated from 17°C to 142°C in 14 minutes.

Long Life in Chemical Milling Service

Chemical Contour Corporation, Downey, Calif., has used three of these tantalum immersion heaters in chemical milling service since November 13, 1957.

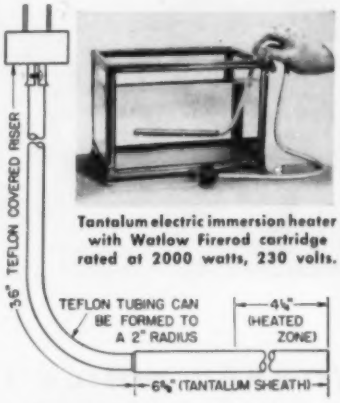
They are used in 55 gallon drum-size tanks to heat acid solutions for dissolving stainless steel. The acid is heated from room temperature to 160°F in approximately 1¾ hours, and is held to within ±5°F by intermittent heater operation.

President James H. Langworthy says: "The tantalum sheathed heaters are extremely versatile. They are easy to move, require little or no support, are easily bent to convenient shapes, are not fragile and can heat acid solutions at a great variety of depths."

Closely Regulated Electroplating Baths

Another company uses this heater in a Watts nickel plating bath to heat this acidic solution and to hold it at 130°F. The fact that tantalum is inert to the solution virtually eliminates the metal ion contamination problem. After the first seven months of service, the heater saw 3500 hours of service with no sign of impaired performance.

Ask for our bulletin on this versatile tantalum electric heater. Tantalum corrosion data are also shown on page 748 of Chemical Engineering Catalog.



Tantalum electric immersion heater with Watlow Firerod cartridge rated at 2000 watts, 230 volts.

Dimensions are shown in drawing. Teflon covered riser can be easily bent to a two-inch (min.) radius for desired positioning.

Free Tantalum Test Kit

A corrosion test kit, available without charge to research technicians, if requested on your letterhead; contains both tantalum sheet and wire.

Free Technical Information

The above condensation is typical of the articles which appear in CORROSIONOMICS, a Fansteel publication. Mail us your name for inclusion on our free mailing list.

For further data on the above, write:

G583A

FANSTEEL METALLURGICAL CORPORATION

CHEMICAL EQUIPMENT DIVISION

NORTH CHICAGO, ILLINOIS, U. S. A

***Mfg. and copyrighted by Watlow Electric Mfg. Co., St. Louis, Mo.*

**Trade Name, E. I. duPont deNemours & Co., Inc.*

EUSEC TO CONVENE IN NEW YORK

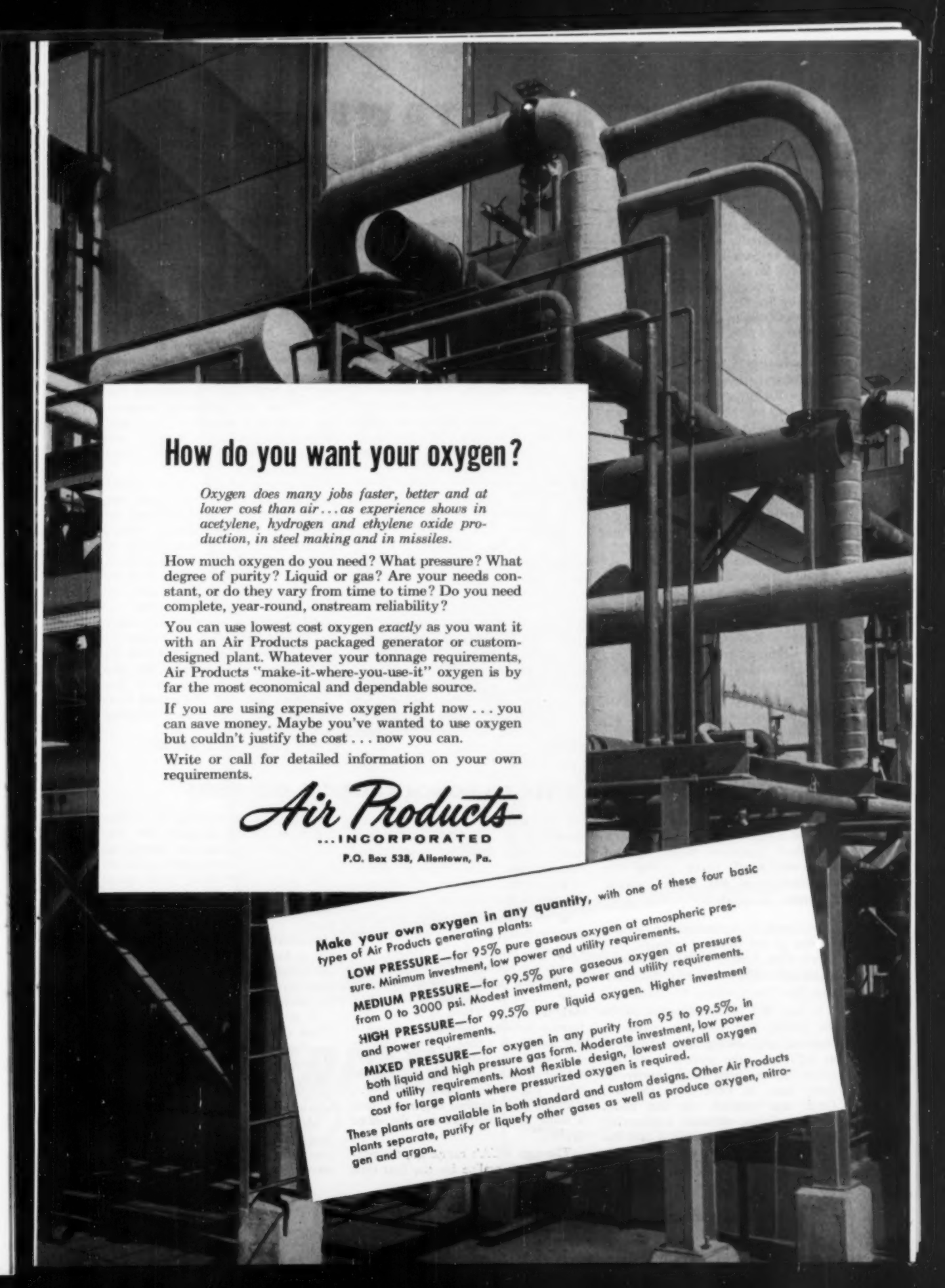
The five Founding Societies will be hosts to officials of the Engineering Societies of Western Europe and U.S.A. at a convention in New York April 28 through May 2, 1958. Clarence E. Davies is administrator for the conference which will bring together the leaders of the engineering organizations of Austria, Belgium, Denmark, Finland, France, Western Germany, Holland, United Kingdom, and United States. In the past, this group has standardized the engineering nomenclature and common bases of engineering education for the countries concerned.

The agenda for the conference includes many items of importance to international engineering cooperation. Among these are: supply and demand of professional engineers, engineering education in Russia, international abstracting services in engineering fields —emphasizing standards and definitions for acceptable engineering abstracts, engineering education and training, consulting engineers, relations with non-profesional organizations, specialty boards, exchanges of visiting lecturers, conservation of natural resources, impact of new techniques and developments (nuclear energy, automation, digital computers), technical investigations, homes of societies, manuals for emigrating engineers and exchange students, and organizations of specialized groups in engineering.

WANTED

Old pictures. Do you have old snapshots of significant people and events of the early days of chemical engineering? CEP would like to borrow your best ones for possible use in the May Jubilee Issue. We would need them by April 1; they will receive good care and will be returned.

There is a new publication in the field of engineering economics. Called *The Engineering Economist*, the new periodical is published by the Engineering Economy Division of the American Society of Engineering Education, is quarterly, will cost $3.00 a year. Checks should be sent to the editor: Prof. Arthur Lesser, Jr., Dept. of Industrial Engineering, Stevens Inst. of Tech., Hoboken, N. J. □



How do you want your oxygen?

Oxygen does many jobs faster, better and at lower cost than air . . . as experience shows in acetylene, hydrogen and ethylene oxide production, in steel making and in missiles.

How much oxygen do you need? What pressure? What degree of purity? Liquid or gas? Are your needs constant, or do they vary from time to time? Do you need complete, year-round, onstream reliability?

You can use lowest cost oxygen *exactly* as you want it with an Air Products packaged generator or custom-designed plant. Whatever your tonnage requirements, Air Products "make-it-where-you-use-it" oxygen is by far the most economical and dependable source.

If you are using expensive oxygen right now . . . you can save money. Maybe you've wanted to use oxygen but couldn't justify the cost . . . now you can.

Write or call for detailed information on your own requirements.

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Make your own oxygen in any quantity, with one of these four basic types of Air Products generating plants:

LOW PRESSURE—for 95% pure gaseous oxygen at atmospheric pressure. Minimum investment, low power and utility requirements.

MEDIUM PRESSURE—for 99.5% pure gaseous oxygen at pressures from 0 to 3000 psi. Modest investment, power and utility requirements.

HIGH PRESSURE—for 99.5% pure liquid oxygen. Higher investment and power requirements.

MIXED PRESSURE—for oxygen in any purity from 95 to 99.5%, in both liquid and high pressure gas form. Moderate investment, low power and utility requirements. Most flexible design, lowest overall oxygen cost for large plants where pressurized oxygen is required.

These plants are available in both standard and custom designs. Other Air Products plants separate, purify or liquefy other gases as well as produce oxygen, nitrogen and argon.

NEW PROCESS POWER FROM ORGANIC WASTES

A new high-temperature, high-pressure process for the treatment of waste liquors from paper mills will receive its baptism this year in Norway. A $3,000,000 installation, now under construction at Sarpsborg, Norway, will be the first large-scale test of the Zimmermann process, developed and licensed by Sterling Drug Co. Licensee is Aktieselskapet Borregaard, Norway's largest pulp and paper manufacturer (*1*). Calculations by Borregaard's engineers indicate that steam produced in excess of process requirements will represent the equivalent of 60,000 tons of imported fuel oil to a value of more than $1,500,000 annually.

The Problem

Disposal of waste liquors has long plagued the pulp and paper industry; in numerous cases, State and Municipal restrictions have blocked the use of otherwise technically and economically desirable pulping processes. Stream pollution regulations have prohibited discharge of pulping wastes into rivers; atmospheric contamination factors have complicated burning of the wastes. For example, when sulfite liquor is burned in boiler installations, about ⅔ of the contained sulfur is released to the atmosphere as SO_2.

Additional complicating factors have been the economic necessity of recovering and reusing the pulping chemicals, and the recovery of other potentially valuable constituents of the waste pulping liquors.

The Process

If claims are accurate, Sterling's Zimmerman process may offer hope for a solution of many of the social and economic problems associated with organic waste disposal, not only in the pulp and paper industry, but wherever such wastes constitute a nuisance and/or a potential source of additional by-product revenues. The method is said to dispose of the waste efficiently and to remove it as a source of stream pollution. When the fuel content of the waste is adequate, as in pulping liquors, it can convert the waste into useable power—either process steam or electricity. Finally, valuable inorganic constituents of the waste can be recovered.

Heart of the process to be used in Norway is a giant high-pressure reactor, built by A. O. Smith of Milwaukee. Weighing 176,000 lbs., the vessel is 68 ft. long and 7 ft. in diameter, is lined with ⅛-in. stainless steel, type 316. For almost complete (90-95%) combustion of the pulping waste, high temperatures and, consequently, high pressures are demanded. The reactor at Sarpsborg will operate at approximately 150 atmospheres pressure, and at temperatures near 600° F.

The projected flow scheme for the Borregaard plant is simplicity itself. Sulfite liquor is preheated to about 300° F. by heat exchange with outcoming liquor, and is pumped continuously into the reaction vessel which stands at a constant pressure of about 150 atmospheres. Combustion air is supplied to the reactor by multi-stage compressors. During combustion, the greater part of the liquor (about 60%) vaporizes, and this water vapor leaves the reactor together with the nitrogen of the air and the carbon dioxide that is formed by the oxidation of the organic materials. Once at temperature, the combustion reaction is self-sustaining. The gases and the steam are separated from the remaining unvaporized liquid in a separator. This liquid phase also contains the inorganic ash constituents, which can be recovered later if desired.

The energy contained in the exhaust gases and steam from the reactor can be used in a variety of fashions, depending on whether electric power, process steam, or a combination of both is desired. At the Norwegian plant, pure steam will be separated from the gas-steam mixture, after which the streams will be conveyed to their respective turbines which jointly supply the driving force for the air compressor. The steam turbines will then deliver low-pressure steam to the pulp mill. Borregaard expects to be able to utilize about 90% of the total heating value of the liquor, including volatile constituents.

(*Continued on page* 132)

1958 CHEMICAL PROGRESS WEEK TO HONOR CHEMICAL ENGINEERS

The 50th Anniversary of A.I.Ch.E. will be a major theme of this year's Chemical Progress Week, to be observed April 14-18 under the sponsorship of the Manufacturing Chemists Association.

Designed to dramatize the contributions of the chemical industry, this year's Fifth Annual CPW will take as a theme—"The Chemical Engineer and His Contributions to Mankind."

It was 1888, MCA will point out to the public, that the first course in chemical engineering was established at MIT. But the profession did not come into its own until exactly 20 years later, in 1908, when the A.I. Ch.E. was founded. At that point, MCA explains, chemical engineering was recognized as "a separate and distinct profession, and with the Institute actively promoting chemical engineering training and systematizing knowledge in the field, growth was rapid. Today there are over 80 colleges and universities teaching chemical engineering, and over 100,000 practitioners in the industry."

In its special literature published and distributed nationally for Chemical Progress Week, MCA points out, "there is a marked difference between the chemist and the chemical engineer . . . in training and in the work each does . . . There is a vast difference between making something a few pounds at a time . . . and making it *economically*, thousands of pounds at a time in large tanks and vessels and other engineering equipment . . . chemists and chemical engineers form a team: one discovers and the other applies."

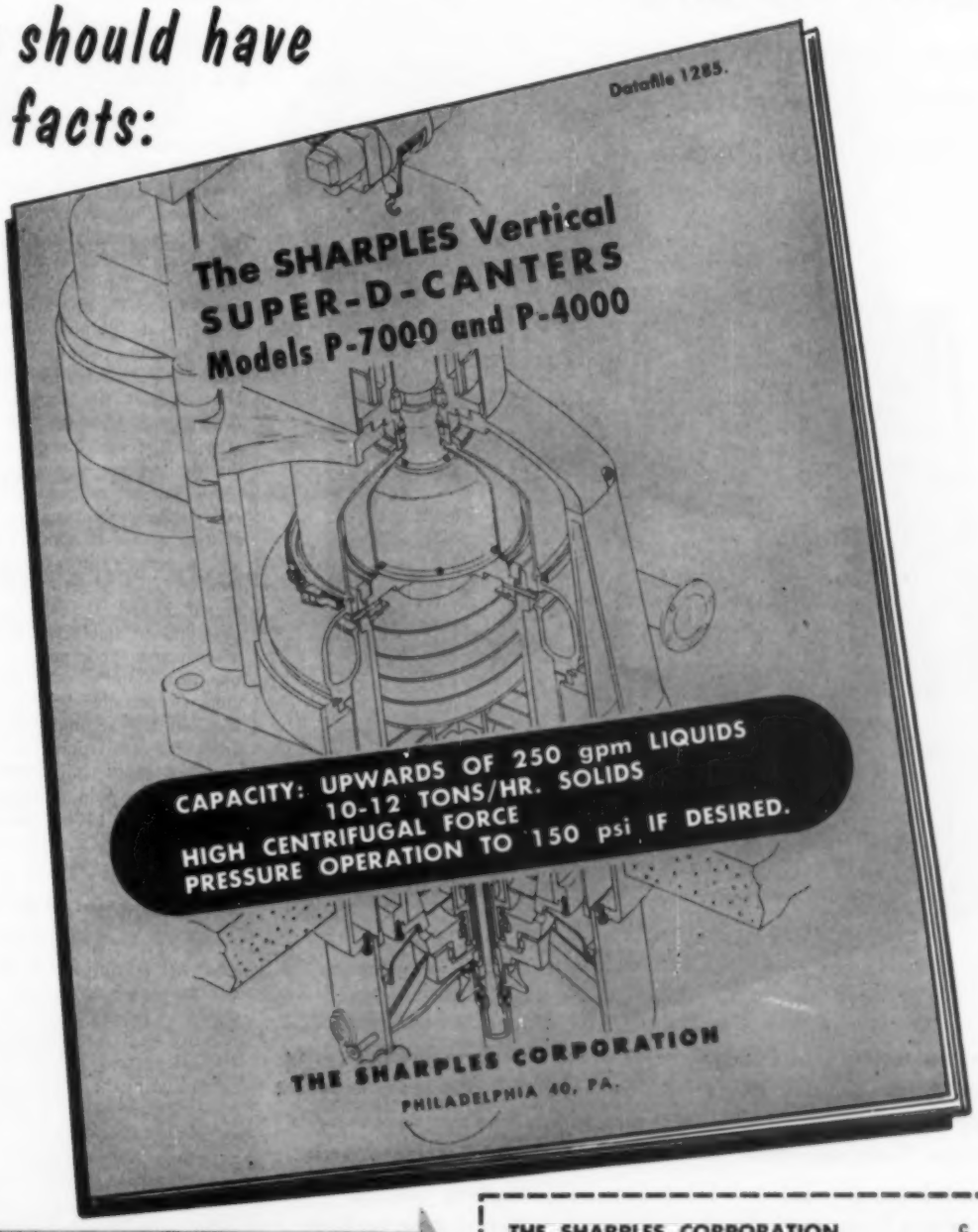
Through MCA's campaign, the public may well realize for the first time that chemical engineering is not limited to design and operation, but "embraces such activities as process research, process development, plant design, plant construction, plant operation, product development, technical sales, technical service, and management." MCA's emphasis on the chemical engineer this year will go into detail on his contributions to the chemical industry ranging from petroleum refining, through the atom bomb, to the production methods for antibiotics.

In its intensive Chemical Progress Week campaign, MCA makes use of speeches, radio scripts, booklets, news stories, special science features, and many other media—especially media designed to reach the young people who are only now deciding on a career.

MCA's bow to A.I.Ch.E. on its 50th Anniversary promises to be another important part of the year-long observances of A.I.Ch.E.'s Jubilee.

IF YOU DEWATER SLURRIES...

You should have the facts:



FILL OUT AND MAIL COUPON OR WRITE ON YOUR OWN LETTERHEAD TO:

SHARPLES

THE SHARPLES CORPORATION C
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Please send me Sharples Datafile 1285.

Name_____

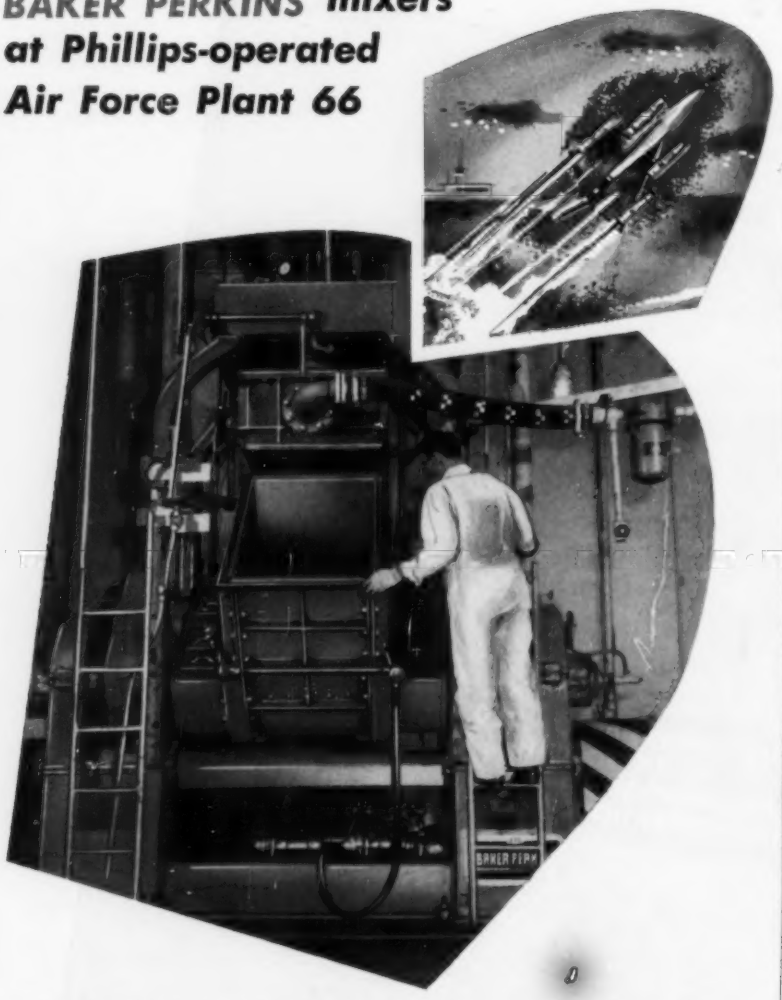
Title_____

Company_____

Street_____

City and State_____

Jato motor fuel is accurately blended in* BAKER PERKINS *mixers at Phillips-operated Air Force Plant 66*



Jet-assisted-takeoffs* (JATO) enable heavy aircraft to become airborne quickly and safely from limited length areas. For the precise task of mixing all-important rocket fuel used in these powerful JATO units, Phillips Petroleum Company, McGregor, Texas, uses dependable Baker Perkins Size 15 Dispersion Mixers.

A combination of vacuum-and-compression cover effectively seals the 15 VUEM2 B-P mixer, which is completely jacketed. Each of these machines has a working capacity of 100 gallons and a total capacity of 200 gallons. The 150 hp drive motor efficiently powers these units thru hour after hour of reliable, trouble-free operation.

This is just one of the many processes to which B-P high-performance mixers are instantly applicable. Write for the complete Baker Perkins catalog . . . or consult your experienced B-P sales engineer.

BAKER PERKINS INC.

354

CHEMICAL MACHINERY DIVISION • SAGINAW, MICHIGAN

INDUSTRIAL NEWS

ZIMMERMANN

(*Continued from page* 130)

U. S. Know-how

Borregaard's decision to proceed with construction of a full-scale plant based on the Zimmermann process, rests not only on laboratory and pilot plant data, but also on the results from a small commercial installation at the Erie plant of the Hammermill Paper Co. in the United States (*2*). This plant, placed in operation in January, 1954, treats pulping liquors from a semi-chemical pulping operation using sodium sulfite cooking liquor. Sterling Drug, under the direction of F. J. Zimmermann, inventor of the process, provided general design and engineering supervision.

At Hammermill, oxidation is carried out in three reactors connected in series, at a pressure of about 800 lb./sq. in., and a temperature of approximately 495° F. The reactors are of 34 in. diameter, and 30 feet high, fabricated of stainless steel clad plate. Results, after some three years of successful operation, show that oxidation efficiency approaches 90%, and that about 90% of the sodium sulfate resulting from the oxidation reaction can be reconverted to sodium sulfite and returned to the pulping operation. Corrosion is said to be practically nonexistant.

Other Applications of Wet Combustion

The principle of wet combustion need not by any means be confined to the pulp and paper field from which the first impetus has come. Zimmermann himself, in 1944-45, applied the method successfully to the production of vanilla at the Salvo Chemical Corp. in Rothschild, Wis., which he founded in 1937, and of which he remains president, although the firm itself has become a subsidiary of Sterling Drug.

In Chicago the process is presently being used by the Metropolitan Sanitary District to evaluate its efficiency in disposing of sewage sludge. After about six months of study, results are said to be "encouraging."

Literature Cited

1. "The Zimmermann Process for the Cellulose Industry," Finn Blikstad, *Norsk Skogindustri No. 5*, Oslo (1956).
2. "Oxidation of Spent Semichemical Pulping Liquors by the Zimmermann Process," Jackson & Brown, *Pulp & Paper*, p. 69 (Feb., 1958).

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DIRECT OR INDIRECT HIGH TEMPERATURE HEATING for the PETROLEUM AND CHEMICAL INDUSTRIES

DIRECT HEATING
of hydrocarbon oils, gases, for gas cracking, steam superheating and many other services.

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using Dowtherm, Aroclor, heat transfer oil, liquid metals and other heat transfer mediums.

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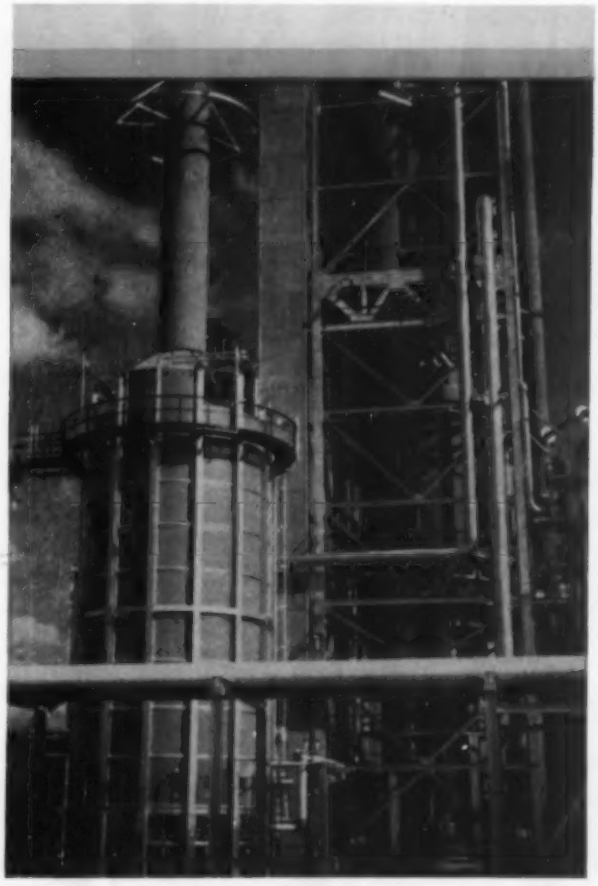

The photos show two tar separator heaters installed at a new refinery in Mississippi. These heaters are provided with alloy tubes, capacity 54,000,000 BTU per hour each. A total of seven Struthers Wells fired heaters were installed in this plant.

Struthers Wells supplies high-temperature heating equipment for a wide variety of services and industries. Temperatures range to above 1650°F. Struthers Wells heaters are characterized by trouble-free operation, long life and high thermal efficiencies. Hundreds of installations throughout the U.S. and some 15 foreign countries indicate the universal acceptance of Struthers Wells fired heaters.

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WARREN, PA. Struthers Wells *Offices in Principal Cities*

Plants at Warren, Pa. and Titusville, Pa.

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Crystallizers . . . Direct Fired Heaters . . . Evaporators . . . Heat Exchangers . . . Mixing and Blending Units . . . Quick Opening Doors . . . Special Carbon and Alloy Processing Vessels . . . Synthesis Converters

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Crankshafts . . . Pressure Vessels . . . Hydraulic Cylinders . . . Shafting . . . Straightening & Back-up Rolls

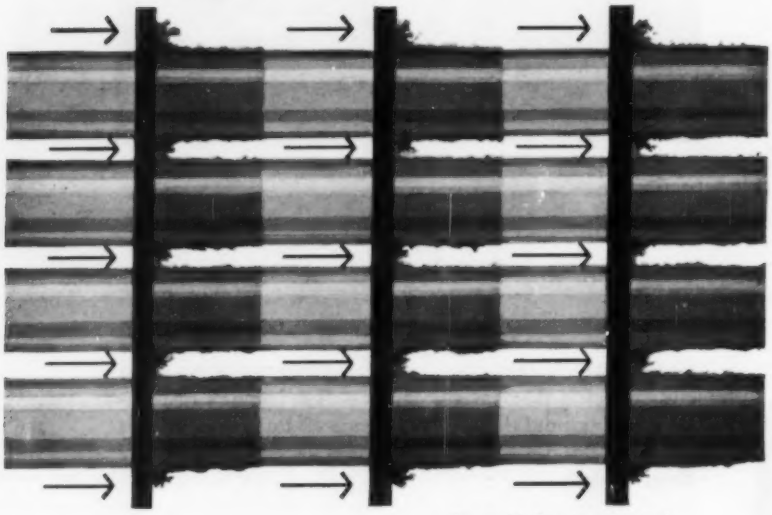
How a Paracoil "clean shave" gives you better heat transfer

Back and forth go the baffles . . . like blades . . . along the tube surfaces . . shaving away accumulations of fouling materials . . cleaning the heat exchanger . . . and giving process plants continuous, increased and better heat transfer.

This is the unique and principal feature of the Paracoil Self-Cleaning Heat Exchanger. Engineered with movable baffles, operated manually or by timed and automatic motor drive, stationary tubes are scraped and "shaved" free of fouling materials which are then carried away in the liquid.

The Paracoil Self-Cleaning Heat Exchanger eliminates the need to stop processing for cleaning purposes.

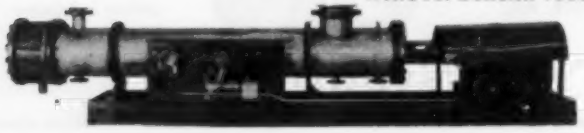
If you have a fouled heat exchanger problem, we may have the answer.



Davis Makes it — Better!

Below: Paracoil Vegetable Oil Chiller for converting a batch process to continuous cycle operation. Constructed of stainless steel and with an automatically timed, self-operating, self cleaning baffle assembly. The unit is presently improving product quality and rate of production in a vegetable oil processing plant.

Write for Bulletin 1000



DAVIS ENGINEERING CORPORATION

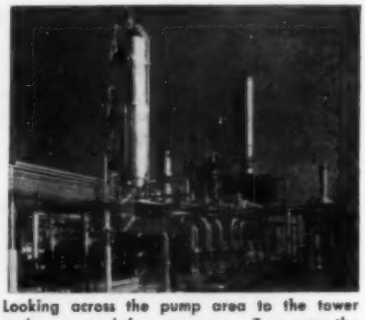
30 Rockefeller Plaza, New York 20, New York • Circle 6-5650

NEW DESULFURIZATION UNIT GOES ON-STREAM IN FRANCE

Designed and constructed by M. W. Kellogg, the new Desulfurization unit is operating at the Provence Refinery of Compagnie Francaise de Raffinage located at Martigues, France.

Designed to remove 85 per cent of the sulfur from 12,500 bbl./day of an 80/20 blend of virgin gas oil and light catalytic cycle oil, the new unit will also accommodate straight-run naphtha and kerosene as alternate feed stocks. With the alternate feedstocks, desulfurization to about 75 per cent is expected.

Most equipment was designed for the 12,500 bbl./day gas oil operation, but some pieces have an increased capacity to permit the throughput of 10,000 bbl./day of straight-run naphtha. With kerosene, the throughput is 7,000 bbl./day which is a balance between the degree of severity required for desulfurization, and adequate product color.



Looking across the pump area to the tower exchanger and furnace areas. Tower on the left is the stripper tower of the new unit.

A two reactor system is provided to give operational flexibility. Design space velocity for the gas oil operation can be maintained while operating the plant at 50 per cent of capacity.

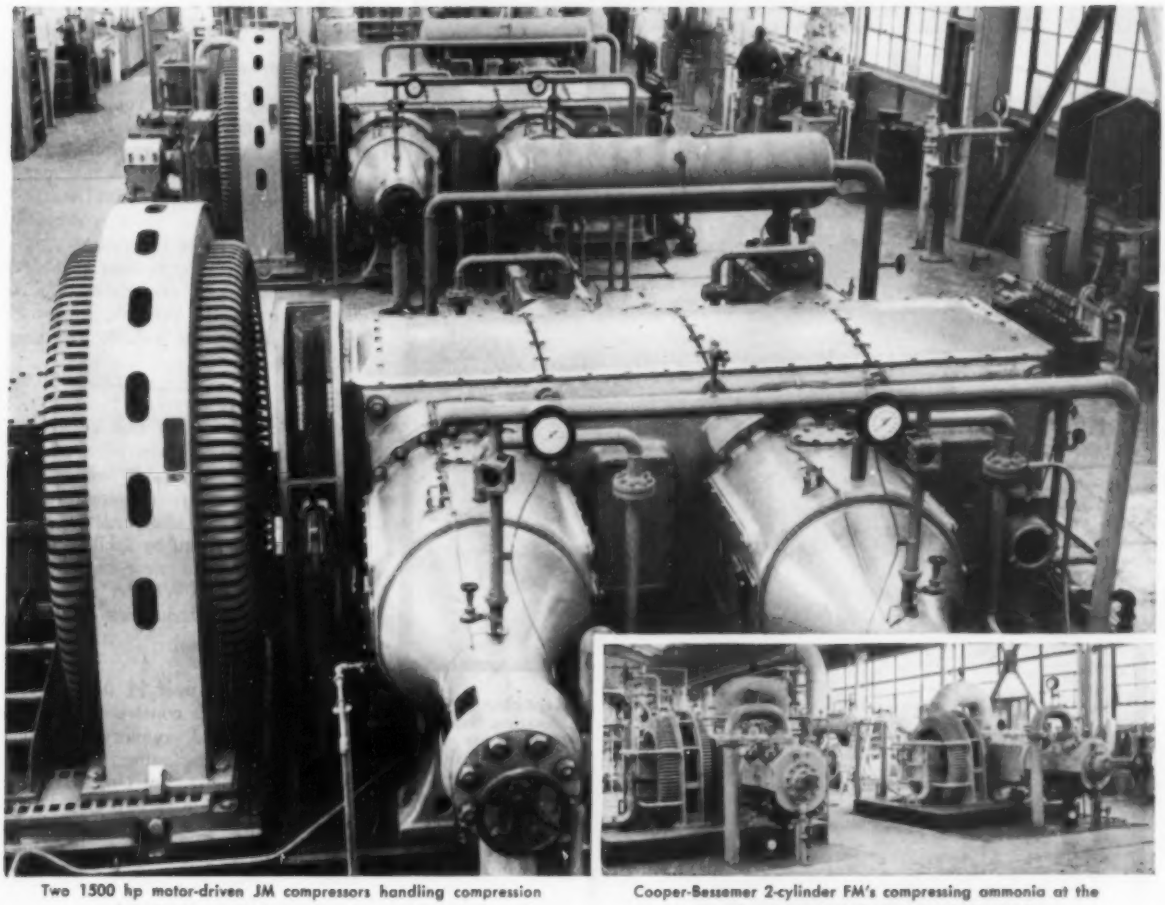
A summary of the unit's operations is:

	Gas Oil	Kerosene	Naphtha
	(bbl./day)		
Fresh Feed	12,500	7,000	10,000
Product	11,900	6,976	10,007

Cobalt molybdate catalyst is used for the reaction in the unit, and the various conditions of the catalytic process are the result of research by both Kellogg and Raffinage.

The new unit uses a novel method of reactor effluent separation. Instead of

(*Continued on page* 136)



Two 1500 hp motor-driven JM compressors handling compression of synthesis gas, before conversion to ammonia.

Cooper-Bessemer 2-cylinder FM's compressing ammonia at the Tuscola plant of U. S. Industrial Chemical.

In Ammonia Service for U.S.I....

high efficiency Cooper-Bessemer Compressors

This installation at the Tuscola, Illinois plant of U. S. Industrial Chemical Co., a division of National Distillers and Chemical Corp., is typical of the many processing plants using reliable Cooper-Bessemer compressors.

Here, two 4-cylinder JM compressors, each rated 1500 hp, handle compression of synthesis gas; and two 2-cylinder FM compressors, each rated 300 hp, handle the compression of ammonia.

These modern, natural force balance Cooper-Bessemers retain the long-life qualities of much larger slow speed units. The M-Line is exceptionally compact without sacrificing accessibility or ruggedness. They conserve valuable space, reduce over-all installation time, and require less investment in foundations and piping.

Available from 200 to 6000 horsepower, each M-Line compressor unit is engineered to meet specific requirements with extreme efficiency and at the lowest possible cost. The nearest Cooper-Bessemer office will gladly furnish detailed information.

BRANCH OFFICES: Grove City • New York • Chicago • Washington • San Francisco • Los Angeles • Houston • Dallas • Odessa • Minneapolis • New Orleans • Shreveport

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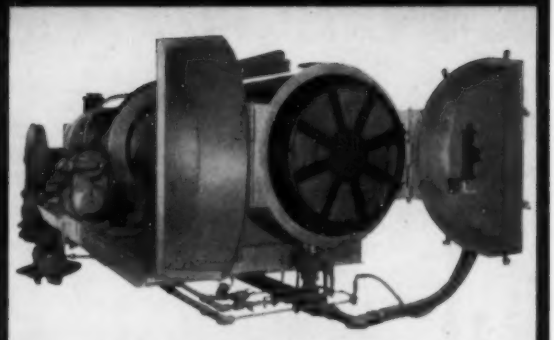
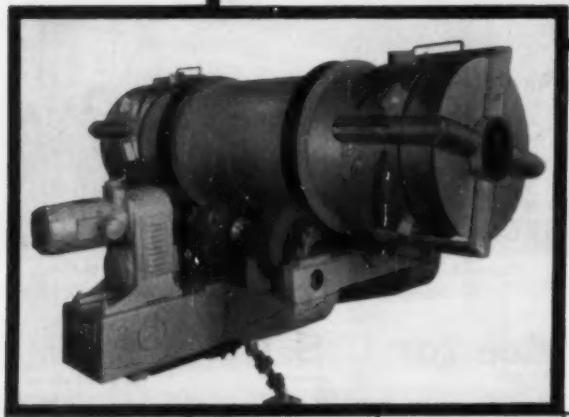
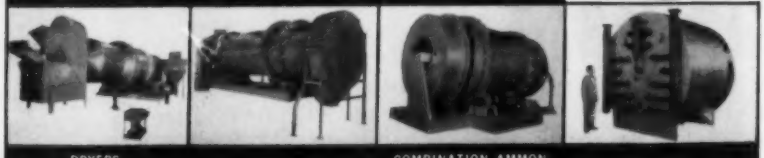
Special Renneburg gas-fired indirectly-heated stainless steel Batch Dryer for calcining Urea product.





Renneburg Rotating Batch Reactor for starch-dextrine material. Has quick-opening ends, rubber tire drive and hydraulic tilting mechanism.

SERVING THE PROCESS INDUSTRIES FOR OVER 80 YEARS



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Literature and information on request

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2639 BOSTON STREET, BALTIMORE 24, MD.

OVERSEAS NEWS

(*Continued from page* 134)

the customary scheme of cooling, flashing and stripping, a progressive flash and recycle gasoline absorption method is said to permit a much higher percentage of hydrogen in the reactor recycle gas stream. Since combined liquids can be sent to the product stripper, there is a saving in heat and heat exchanger surface, and these liquids do not have to be reheated allowing the saved heat to be used to heat the feed oil.

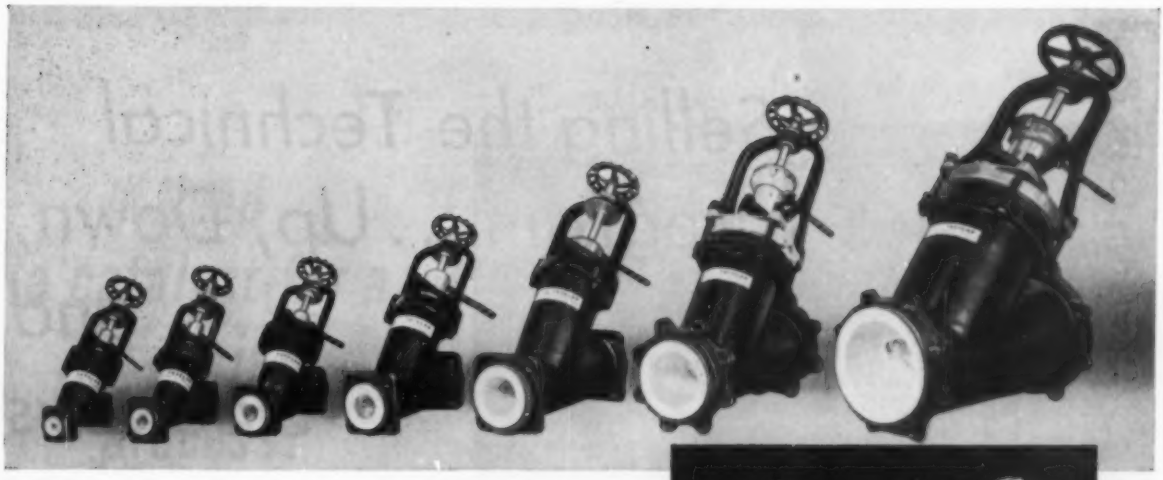
Design, engineering, and construction of process plants for refining of petroleum, vegetable oils, fatty acids, and for the manufacture of various industrial chemicals will be carried out in Japan by Ishikawajima Foster Wheeler, a new corporation formed by Foster Wheeler and Ishikawajima Heavy Industries of Tokyo. □

The first Udex unit in the United Kingdom is under construction at the Stanlow, England, refinery of Shell Refining and Marketing, Ltd. Designed and licensed by Universal Oil Products, the unit is expected to be in operation by mid-1958, will produce an aviation gasoline blending component. □

Leje & Thurne of Stockholm, Sweden, exclusive representatives of Sprout-Waldron's Pulp and Paper Mill Division in Sweden, will now also represent Sprout-Waldron in Germany, Austria, and Holland. □

A cumene manufacturing plant to be erected at Grangemouth, Scotland, for British Hydrocarbon Chemicals, Ltd., will be designed by Scientific Design Co. of New York. The process to be used, originally developed by Scientific Design, has been licensed to the British company by Mid-Century Corp., a subsidiary of Standard Oil (Indiana) which acquired world-wide rights to the process last year. □

A fume absorption plant will be designed and built by Kellogg International for the United Kingdom Atomic Energy Authority (England). The unit will form part of a major plant for the processing of uranium to be built at UKAEA's Springfield Works, near Preston, Lancashire, and will recover nitric acid from nitrous fumes arising from three sections of the main plant. □



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LAPP SOLID PORCELAIN VALVES WITH TUFCLAD® ARMOR

Install Lapp Solid Porcelain acid proof valves and have that trouble-free chemical line you want—at a cost well within budget. With Lapp Valves in your system, you have the assurance of *purity, protection* and *permanence.*

Because of its many special characteristics, Lapp Chemical Porcelain is the *ideal material* for maintaining *strict purity.* It is chemically inert, therefore resistant to corrosion from acids of all concentrations (except hydrofluoric); it's hard, dense, pure, homogeneous, close-grained and non-porous. Impregnated and bonded to this porcelain by an Epoxy resin of high strength and chemical resistance is an armor consisting of multiple layers of strong fiberglass. This serves as an insulator against thermal shock, a cushion to accidental impact and is strong enough to hold operating pressure even if porcelain is fractured. Built-in seating handle, solid Teflon packing, spring washers, malleable iron trim and brass stud and bushing are other advantages that make Lapp Valves well worth your investigation.

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CHEMICAL PORCELAIN

WRITE for description and specifications. Lapp Insulator Co., Inc., Process Equipment Division, 2300 Chestnut St., LeRoy, N. Y.

Selling the Technical Program . . . Up, Down, and Sideways

PART II

"Many thousands of dollars may be spent in executing a brilliant piece of technical work but it's not worth a nickel to the company unless the results are used by the customers."

The problem is "selling" a technical program—selling it upward, to top management; sideways to manufacturing, production, sales or clients; and downward *from* top management. At a recent A.I.Ch.E. meeting,* E. B. Savage, Jr. of Savage-Lewis Inc., H. D. Wilde of Humble Oil & Refining, and P. C. White of Standard Oil (Indiana) analyzed just how to go about this vital "selling."

Top Down

Selling downward from management comes first. As White pointed out, "If a research director assumes his staff has a full understanding of the significance of various research projects, he is usually making a grave error." A recent survey covering thousands of technical personnel in many companies showed, according to White, that over one-third of the people were not sure that the aims, goals, and purposes of research in their companies were clearly established. An even larger percentage, 40%, doubted whether these aims, goals, and purposes were known and understood by the research staff. "It is truly hard," said White, "for the senior research supervisor to appreciate how wide the gulf is between himself, with his years of experience [in the company], and the younger man who shares his technical background and enthusiasm but who lacks his almost intuitive understanding of the whys and wherefores of the research program."

To bridge this gulf, White recommended five methods.

1) Promote the establishment of company objectives by top management. This means more than generalized objectives such as "improving products, cutting costs." It means specific objectives as to why and where the company is going.

2) Once the objectives are set, top management should back them up with a continuing flow of downward information on company policies, changes in plans, competitive trends, economic trends, etc. Make the research man a part of the management team.

3) Let the research men know the terms under which the project was sold to management and management's reaction. They should know the details of time limitations, dollar limitations, and the specific objectives of their project in the overall company picture.

4) Once the job is finished, the research workers should be told all the non-technical factors which may enter into management's decisions on the fate of the project; the reasons, the possible delays, and the work other departments will have to do in connection with the project.

5) Finally, if the job is turned down in the end, the research workers should know why—in detail and candor.

Bottom Up

". . . the report to management is the most effective tool a [non-management] chemical engineer can use—and also the most misused . . ." With this introduction, Savage took up the consideration of the upward flow of information, selling the technical program to management.

The report to management on the proposed project is the basic tool for communicating upwards—whether it is written or oral. Normally, each company has "channels" for communication upward, but, Savage emphasized, in many companies the formal organizational channels have little in common with the way the business actually communicates. "Our studies show that most (engineers) who get things done just don't always 'go to the boss.'" He concedes that this may be heresy, but it is true. Official channels have a way of becoming snarled in their own system. One of the basic reasons for this is that, beginning at about the V-P level, executives are extremely busy men whose own habits of reading or listening may leave much to be desired. Too often the technical man writing his report forgets that the boss will probably have only some ten minutes to an hour to read it, digest it, and understand it. The technical man must remember that a technical project which is his *main* concern, is just one of many concerns to the boss.

But companies do manage to communicate. How? Savage said, "If I can give one, all-inclusive formula . . . those that get through have a very simple pattern." A written communication has a functional system based on the natural functioning of the human mind. This means that all technical reports must have a beginning, a middle, and an end. Putting it more technically, a report should state the problem, present the body of work as simply as possible, and come to a concise conclusion.

Savage concluded his analysis with eight tips on good report writing aimed upwards: 1) be coherent; 2) be single-minded, stick to the subject;

(*Continued on page* 140)

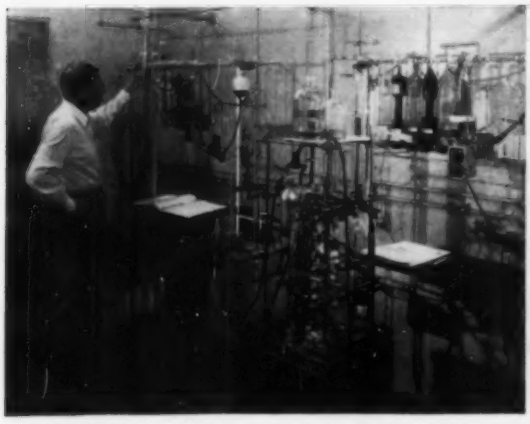
* Chicago, Annual Meeting, Dec. 8-11, 1957.

Need a catalyst for a special process?

Girdler can help you!

Catalyst Research is an important part of Girdler's full-scope catalyst service to assure you optimum performance . . . lowest operating cost. Girdler Research teams up with your technicians to custom-design *the* catalyst to meet your requirements.

Write for booklet on Girdler's complete catalyst facilities . . . its Application Service, Research Service, Analytical Service, Manufacturing.



Girdler's highly skilled development staff works on *your* process problem to give you optimum catalyst performance.

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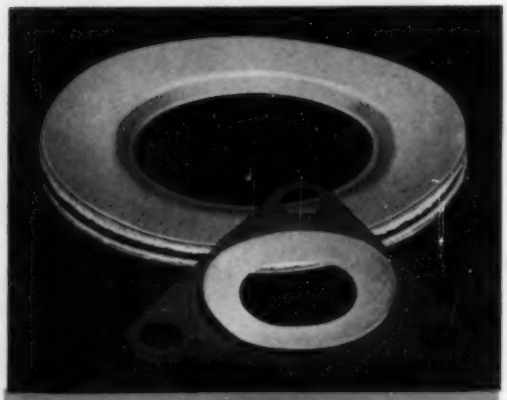

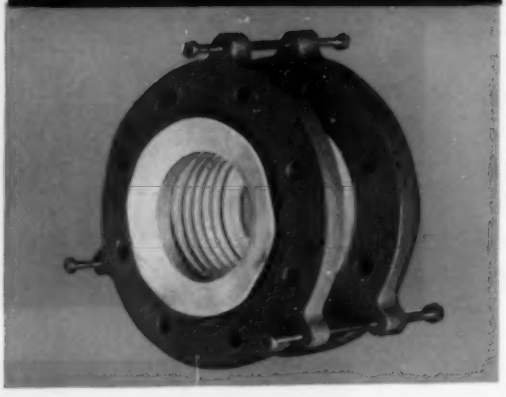

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. . . and Flexible Couplings, made of chemically impervious du Pont TEFLON, protect costly piping against shock and vibration, thermal expansion and contraction. Correct misalignment. Connect unlike piping ends and nozzles. Eliminate slip-joints, gaskets, adaptors. Companion Products to the famous Garlock Rubber Expansion Joints. Catalog No. AD-137.

For prompt service, contact one of The Garlock Packing Company's 30 sales offices and warehouses throughout the U.S. and Canada, or write

United States Gasket

United States Gasket Company
Camden 1, New Jersey

Plastics Division of GARLOCK

(Continued from page 138)

3) be brief; 4) remember the interests of top management—long-range plans, profit, expenses, etc.; 5) use *his* language not engineerese; 6) compare, report with perspective and relation; 7) be graphic, use graphs, pictures, etc.; 8) be colorful, don't be afraid to "sell" your project.

Selling the Project "Sideways"

A basic fault of engineers is a tendency to feel that their responsibility for a project ceases with the completion of the technical work and a submission of the report upward to top management. This, said Wilde, is not true. "Members of a technical group must be made to realize that technical effort is . . . wasted if the results are ignored by the customers . . ." By customers, Wilde means anyone who must use the results—other departments and divisions of the company, clients, and other technical people in other companies. So, although it takes time and effort, a deliberate and conscious plan must be worked out by a technical group to "sell" its results to those who will actually apply them. The men who have done the technical work must be afforded the opportunity to talk with the men who will use and apply the results. Personal contacts are extremely effective, but should be between men on the working level as well as top management. Again, it is important to be sure you understand your audience and do not become technical when talking to non-technical people.

In Wilde's words, "Much time and effort is required for the adequate selling of a technical program . . . in most cases the initiative must be taken by the technical organization . . . but it is an investment that pays big dividends."

Fifty million lb./yr. of new paraxylene capacity will be added by Sinclair Chemicals at Houston, Texas. It is estimated that, added to the production of Sinclair's older facilities at Marcus Hook, Pa., the new plant will make Sinclair the world's largest marketer of paraxylene. Principal outlet for the new production of paraxylene will be DuPont's dimethylterephthalate (DMT) plant now building at Old Hickory, Tenn. The Houston unit will also turn out about 60 million gal./yr. of pure toluene and mixed xylenes for sale to the chemical industry and for producing high octane gasoline. □

TEXACO

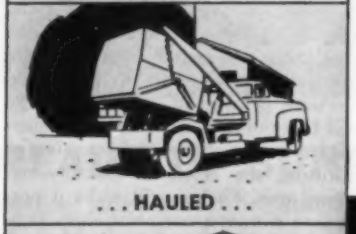
REG. T.M.

The TEXAS COMPANY "CONTAINERIZES" Waste as it Accumulates

Port Arthur Refinery "Containerizes" Waste, Rubbish and Liquids at Many Accumulation Points . . . Hauls and Dumps Them With Dempster-Dumpsters

WASTE IS CONTAINERIZED . . .

. . . PICKED UP . . .



. . . HAULED . . .

. . . AND DUMPED . . .

Dempster-Dumpster Waste Disposal System Serves Leading Refineries & Chemical Plants

Waste disposal and plant cleanliness can no longer be efficiently maintained by wheelbarrows, cans, carts, or bins. Shoveling, re-handling and on-site dumping have been replaced in leading plants by "Containerization" of waste as it accumulates. By placing clean, big-capacity Dempster-Dumpster containers at accumulation points, you can save thousands of dollars annually and enjoy improved plant cleanliness.

The one-man, one-truck Dempster-Dumpster can service over a hundred accumulation points, picking up, hauling and emptying the containers on a planned shuttle schedule. Chemical plants and refineries customarily amortize their equipment investments in 18 months or less. Write today for the free booklet, below.

FREE: Write Today for Your Copy of
"How to Reduce Waste Disposal Costs."

DEMPSTER BROTHERS, Knoxville 17, Tenn., DEPT. CH-3

THE DEMPSTER DUMPSTER® SYSTEM

To: Dempster Brothers, Dept. CH-3
Knoxville, Tennessee

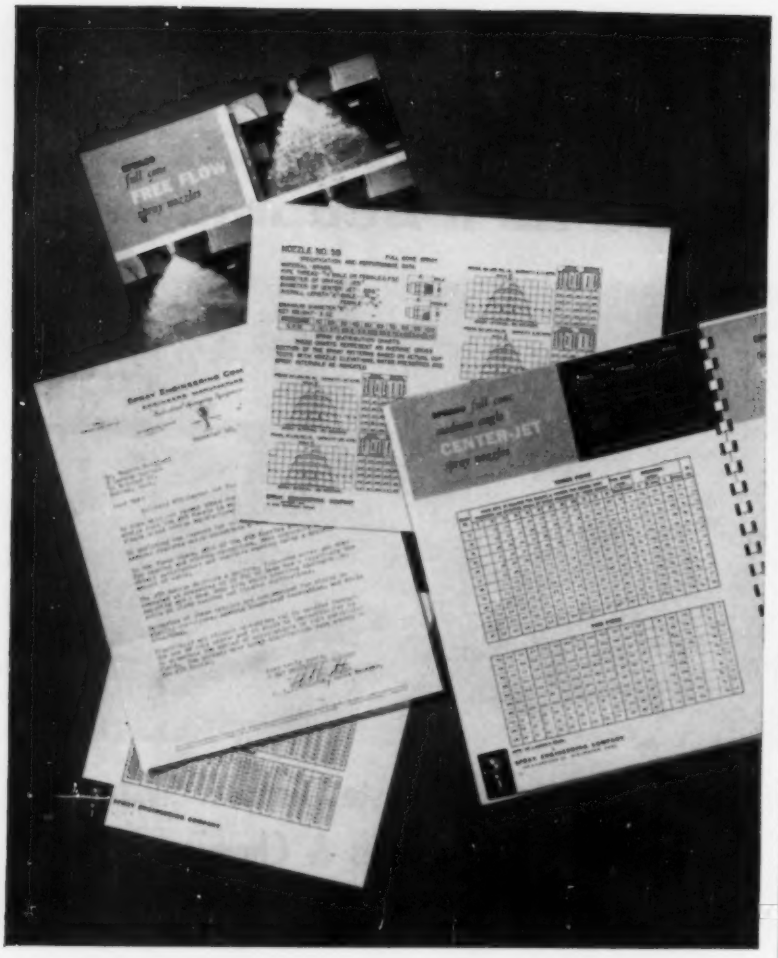
Please Send Without Obligation Your Booklet, "How to Reduce Waste Disposal Costs."

NAME ..... TITLE .....

COMPANY .....

ADDRESS .....

CITY ..... STATE .....



NOW... "SPECS" AT YOUR FINGERTIPS

Here's a surer, easier way to specify spray nozzles

How can you be sure you're specifying the *right* spray nozzle for your particular application?

Spraco's research department has taken the guesswork out of this problem by preparing complete and accurate performance data for each of the hundreds of spray nozzles in the Spraco line. Each nozzle "profile" is complete with data on material, dimensions, flow rate, pressure, angle of spray . . . everything you need to enable you to choose, at a glance, the nozzle that will deliver maximum performance and efficiency in your particular application.

No matter what your spray nozzle problem, Spraco makes this information available to you absolutely free. Why not write and ask about it — today?

SPRAY ENGINEERING COMPANY

132 Cambridge Street, Burlington, Mass.

SPRACO

NUCLEAR NEWS

NEW PROGRAM TO STUDY MECHANISM OF RADIATION-CATALYZED CHEMICAL REACTIONS

With the aid of a new high-energy electron accelerator, Argonne National Laboratory engineers and scientists will attempt to find out directly what happens during a chemical reaction when it is catalyzed or set-off by atomic radiation.

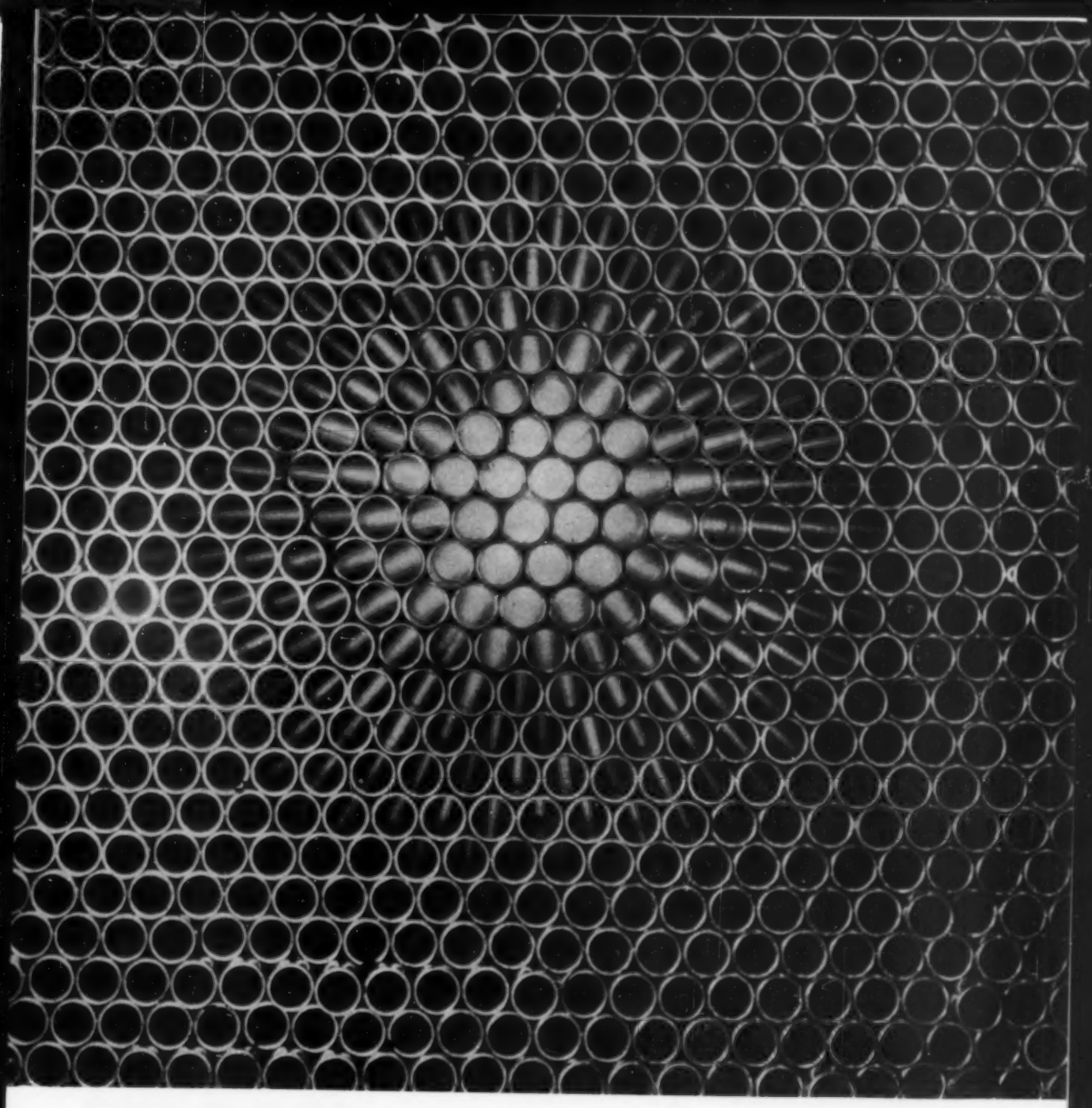
The Argonne research project, which hopes to detect directly the short-lived intermediate products of radiation catalyzed reactions, is expected to be in operation this fall. For decades it has been known that high energy electrons and gamma rays induce chemical reactions. But exactly what takes place is still open to question in most cases. A more complete understanding of the mechanism involved, and the primary intermediate products produced, should help engineers and scientists to use radiation more thoroughly and efficiently for the production of new chemical products.

Applied Radiation Corp., Walnut Creek, Cal., is building the linear electron accelerator which will emit intense bursts of electrons and create short lived ions and free radicals in sufficient concentration to allow direct identification. With the exception of dilute gases, up until now information about the short-lived intermediate products has been deduced largely by working backwards from the end products, or by using reactions that involve substances such as iodine that scavenge free radicals. Since these techniques are rarely definitive, there is disagreement concerning the nature of even some of the better-known reactions.

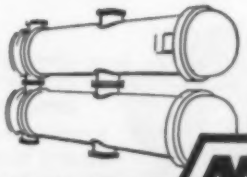
The techniques used will be similar to those now used in flash photolysis. During a single pulse, the Argonne accelerator will emit a 280 milliampere beam of electrons—1,800 million billion electrons per second. Electron energy will be controlled from 1 to 18 million electron volts. Instead of scanning or diffusing the beam, a specially designed exit window will make it possible to extract a one-centimeter-diameter beam without scanning. This full beam can then be directed into a small experimental system. The 15-foot accelerator will cost $225,000.

Argonne plans to use the accelerator to study radiation damage and nuclear chemistry as well as radiation chemistry.

(*Continued on page* 144)



READY TO BUNDLE into heat exchangers for chemical and petroleum service, tubes and other standard components are kept fully stocked for assembly-line production at Kellogg's fabricating shops in Jersey City. Whatever your requirements, Kellogg assures strict conformance to the highest engineering and fabricating standards. For prompt deliveries plus engineering excellence at optimum cost, call Kellogg's Fabricated Products Division.



THE M. W. KELLOGG COMPANY, 711 THIRD AVENUE, NEW YORK 17, N.Y.

A SUBSIDIARY OF PULLMAN INCORPORATED

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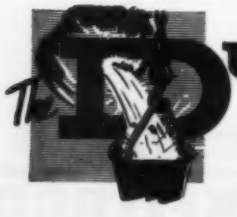
M KELLOGG W

DURALOY

25-20 Casting with Welded Assembly

This is a separator destined for a reaction process. It is typical of the kind of work we do in the high alloy casting field. In the 25 Cr-20 Ni range it is alloyed to withstand both corrosion and heat. Assembled, its weight runs some 2000 pounds. It was inspected and tested under very rigid ASME Code requirements.

The production of chrome iron and chrome nickel castings has been our sole business since 1922. We added centrifugal castings to our service in 1933 and shell molded castings in 1955. Our metallurgists have extensive knowledge of the many operations requiring high temperature and corrosion resistant castings. Perhaps this experience would be helpful to you if you are confronted with a specific problem and wish to determine the best alloying combination for your required castings. We can be helpful, too, in designing the unit, contributing our knowledge of strength and stresses in castings.



The DURALOY Company
OFFICE AND PLANT: Scottdale, Pa.
EASTERN OFFICE: 12 East 41st Street, New York 17, N. Y.
ATLANTA OFFICE: 76—4th Street, N.W.
CHICAGO OFFICE: 332 South Michigan Avenue
DETROIT OFFICE: 23906 Woodward Avenue, Pleasant Ridge, Mich.

NUCLEAR NEWS

(*Continued from page* 142)

More than 3,400 high school students toured laboratories and production facilities of the AEC recently. Purpose of the mass visits, according to AEC Chairman Lewis Strauss, was, ". . . to have a better understanding of what their country is doing in bringing the benefits of the atom to peoples everywhere. I hope that they will gain a real appreciation of the important and exciting opportunities which exist for them in the field of atomic energy and the manner in which they can serve the welfare of mankind." Ten of the Commission's key laboratories and production facilities admitted the students to unclassified areas to stimulate their interest in careers in science and engineering. □

Sustained nuclear fission, or criticality, was achieved recently in an experimental reactor built as an aid in developing the nuclear propulsion system for the N.S. Savannah, world's first atomic merchant ship. Designed and built by Babcock & Wilcox, prime contractors for the N.S. Savannah's propulsion plant, the reactor will be operated during the next few months to check analytical calculations made in the course of designing the ship's propulsion plant.

Scheduled for completion in 1960, the Savannah will be powered by an advanced type of pressurized water reactor. The reactor plant will deliver a maximum of 22,000 shaft-horsepower, and estimates of the power plant's capability run as high as 350,000 miles on a single core loading of nuclear fuel. □

A pioneer reactor in the American nuclear field observed its first birthday on February 9. It is the EBWR (Experimental Boiling Water Reactor) at Argonne main laboratory site in Illinois. In its first year, the experimental reactor operated at 60 per cent of its total capacity for 12 months. It logged, without incident, more than 11,655,000 kilowatt hours of electricity (enough power to permit the approximately 6,000,000 residents of the Chicago area to operate a flatiron for 2 hours). It has provided a steady flow of information on which scientists and engineers have been able to develop methods by which they can predict the behavior of nuclear power reactors of the boiling water type. Its job was to provide research data in the quest for economic nuclear power, and it has done that. □

News from
National Carbon Company
Division of Union Carbide Corporation · 30 East 42nd Street, New York 17, N. Y.
Sales Offices: Atlanta, Chicago, Dallas, Kansas City, Los Angeles, New York, Pittsburgh, San Francisco. IN CANADA: Union Carbide Canada Limited, Toronto

National Carbon representatives expand your engineering force

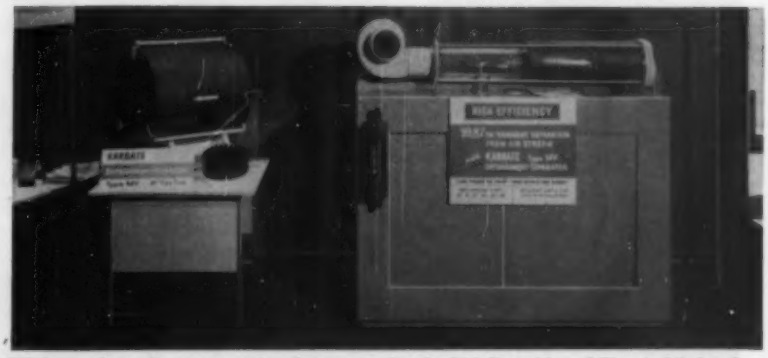
R. L. von HOHENLEITEN,
SALES ENGINEER

Mr. von Hohenleiten has spent the past seven years representing National Carbon Company to the chemical processing and allied industries. He was graduated from Johns Hopkins University with a B.S. in chemical engineering and is a registered professional engineer in Texas.

His first few years with National Carbon Company were spent with an engineering group developing new designs and improving existing designs of "Karbate" chemical processing equipment. Von Hohenleiten was first active as a Sales Engineer on the west coast and is now serving customers in the southwestern section of the country.

Mr. von Hohenleiten is qualified to aid in the selection, special designing and installing of carbon, graphite and "Karbate" impervious graphite processing equipment. Call your National Carbon Sales Engineer today.

"KARBATE" CORROSION RESISTANT ENTRAINMENT SEPARATORS PROVIDE HIGH OPERATING EFFICIENCY



Efficiency of entrainment separators demonstrated at the 26th Exposition of Chemical Industries.

Data collected from many installations prove "Karbate" Impervious Graphite Entrainment Separators – Type MV are an efficient and economical means for removing entrained liquids from gas streams.

For example, one such entrainment separator (installed in a line carrying toluene mist and vapor) helped recover approximately 36 gallons of toluene in five days of operation. With toluene valued at 35¢ a gallon, this represents quite a saving. Although the recovery operation required additional process equipment, the entrainment separator will pay for itself in a short period of time.

These type MV entrainment separators operate through a combination of venturi action and impingement . . . contain no moving parts . . . and are non-clogging. Because liquid and gas contact only "Karbate" impervious graphite, units are virtually immune to corrosion over a temperature range from 40°F. to 338°F.

Standard sizes of "Karbate" entrainment separator – Type MV assemble directly into 6", 8", 12", 16", 20" and 24" horizontal lines. Units are self-contained and ready to install. For details, request **Catalog Section S-6900.**

"KARBATE" ENTRAINMENT SEPARATOR – TYPE MV SEPARATION EFFICIENCY AT AVERAGE FLOW RATE		
Liquid Particle Size Dia. Gr.=1.0 Microns	Percentage Removed from Steam at 2" Hg Absolute	Percentage Removed from Air at 1 Atmosphere
11.3	100	99.6
7.8	100	93
5.1	99.7	46
4.0	98	11
3.4	94	0
1.7	0	0

PACKAGED HCl BURNING, ABSORBING AND STRIPPING SYSTEM TO GO ON STREAM

A complete system to produce anhydrous hydrogen chloride starting with hydrogen and chlorine will go on stream soon at a high energy fuel plant. This integrated system includes the burning of hydrogen and chlorine in a graphite combustion chamber, absorbing the product hydrogen chloride in a "Karbate" falling-film absorption system, and finally stripping the concentrated hydrochloric acid from the absorber in a "Karbate" tower. The system was designed complete with instrumentation and support structures by National Carbon Company.

The system's steps are made up of packaged components using standardized "Karbate" impervious graphite and graphite equipment. "National" engineers will work up the complete system to your specifications. Literature is available on the "AG" system (for producing anhydrous HCl gas) and the "CA" system (for producing hydrochloric acid).

The terms "National", "Karbate", "Union Carbide" and "N" and Shield Device are registered trade-marks of Union Carbide Corporation.

UNION CARBIDE

NATIONAL TRADE-MARK

Finds "Our Paul O. Abbé Mixers GIVE WELL BALANCED PERFORMANCE"

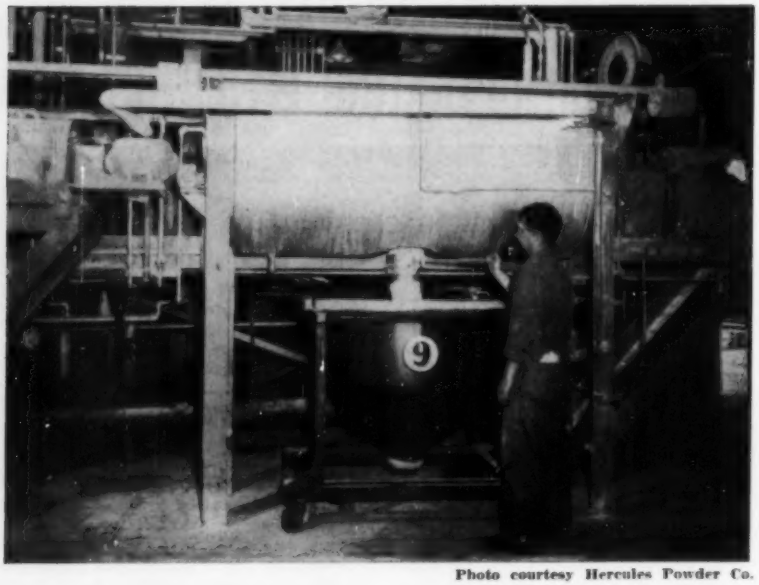


Photo courtesy Hercules Powder Co.

A Well-known Manufacturer Had to Mix Cellulose Acetate with Various Colorants.

They wanted:

1. To get an homogeneous mix.
2. To eliminate any possibility of contamination or discoloration from one batch to the next.
3. To obtain maximum size of the batch.
4. To be able to mix a wide range of formulations without lumping.

They stated that their Paul O. Abbé Mixers have met every need.

"What we were looking for was a versatile mixer—one that met every one of our requirements to a high degree," they state.

"Our Paul O. Abbé Mixers we find give well-balanced service. They are versatile. They rank high in meeting our requirements."

You, too, may find Paul O. Abbé Mixers help you solve YOUR mixing problems.

Write today for Catalog "V-1," describing our line of dry and paste mixers.

PAUL O. ABBE

402 Center Avenue **Little Falls, New Jersey**

future meetings

■ **1958 MEETINGS—A.I.Ch.E.**

• Newark, Delaware, April 2-4, 1958. University of Delaware. **Conference on Automatic Optimization.** Co-sponsored by A.S.M.E. A.I.Ch.E. and other groups. Program will comprise four technical sessions and a panel discussion. **Optima—What They Are and How to Find Them**—G.P.E. Box, Princeton Univ. **Principles of Designing an Optimizing System When Equations Are Not Available**—W. F. Galey, Pitts. Pl. Glass. **Evaluation of Strategies for Automatic Experimentation**—R. I. Van Nice & A. F. Kaupe, Jr. Westinghouse. **An Adaptive Humidity Control System**—G. K. Tucker, Brown Instr. Div. **A Technique for Optimizing Process Conditions**—A. L. Hoerl, DuPont. **Optimizing Transient Stability in Batch Processing**—D. P. Eckman & I. Lefkowitz, Case Inst. **Panel discussion** of problems, challenges, & opportunities in automatic optimization. **Application of Hydraulic Control to Reagent Flow Regulation**—H. Markarian & J. B. Reynolds, Jr., DuPont. **Sheet-Length Gage for Ferrostan Line**—J. A. Milnes, U. S. Steel. **Analysis and Design of Boiler for Optimum Performance**—E. I. Ergin, Beckman Systems Div. **Continuous Measurement of System Characteristics; A Step Toward Self- Optimizing Control**—T. P. Goodman & R. H. Hillsley, MIT. **Servo with Automatic Gain Control**—E. R. Walters, Bendix Radio. **Adaptive Filters for Random Inputs**—C. W. Steeg, Jr., RCA Airborne Systems Lab.

• Philadelphia, Pa., April 8, 1958. University Museum, University of Pennsylvania, 33rd and Spruce Sts. One-day meeting co-sponsored by **Phila.-Wilmington section AIChE and Univ. of Pa.** on **Scale-Up in Practice.** Gen Chmn.: C. H. Collier. **What to Pilot Plant and on What Scale**—H. J. Ogorzaly, Esso R&D. **Basic Principles of Scale-Up**—R. L. Pigford, Chem. Eng. Dept., Univ. of Delaware. **Analog Approaches to Scale-Up**—C. W. Worley, Electronic Associates. **Pitfalls**—Fred Kopf, Atlantic Refining. **Internal Economics**—D. J. Torrans, Hercules. **External Economics**—D. M. Feeley, A. D. Little. **Organizing for Scale-Up**—R. L. Hershey, DuPont.

• Montreal, Canada, April 20-23, 1958. Sheraton-Royal Hotel. **Joint A.I.Ch.E.—C.I.C. Conference.** For details of program see February CEP; latest changes, etc., on p. 152 of this issue.

• Toledo, Ohio, May 9, 1958. Commodore Perry Hotel. One-day meeting of **Ohio, Pittsburgh,** and **Detroit Sections, A.I.Ch.E.** Theme, **"Instrumentation for the Chemical Engineer."**

• Philadelphia, Pa., June 22-27, 1958. Bellevue-Stratford Hotel. **50th Anniversary Jubilee Meeting of A.I.Ch.E.** Gen. Chmn: W. E. Chalfant, Atlantic Refining, Philadelphia, Pa. For program information see page 151.

• Evanston, Ill., August 18-21, 1958. **A.I. Ch.E.-A.S.M.E. Heat Transfer Conference,** Northwestern U. Technological Inst. Tech. Prog. Chmn.: A. S. Foust, Dept. of Chem. Eng., Lehigh University, Bethlehem, Pa.

• Salt Lake City, Utah, Sept. 21-24, 1958. Hotel Utah. **A.I.Ch.E. National Meeting.** Gen. Chmn: R. J. McNally, Amer. Smelting and Refining, Salt Lake City, Utah. Tech. Prog. Chmn.: E. B. Christiansen, Dept. of Chem. Eng., Bldg. 437, Univ. of Utah, Salt Lake City. **Air Pollution**—W. L. Faith, Air Pollution Foundation, 704 S. Spring St., Los

Angeles 14, California. **What's New in Liquid Metals Technology**—Marshall Sittig, American Lithium Institute, Inc., P.O. Box 549, Princeton, N.J. **Crystallization**—H. M. Schoen, American Cyanamid Co., 1947 West Main St., Stamford, Conn. **Foams and Froths**—J. Louis York, Dept. of Chemical Engineering, Univ. of Mich., Ann Arbor, Mich. **Ethylene**—Hermann C. Schutt, 201 Devonshire Street, Boston, Mass. **Polar-Nonpolar Thermodynamics**—J. M. Smith, Dept. of Chem. Eng., Northwestern Univ., Evanston, Ill. **Economics of Non-Petroleum Sources of Energy**— J. M. Hirsch, Gulf Research & Dev. Co., P.O. Drawer 2038, Pittsburgh 30, Pa. **Centrifugation**—J. O. Maloney, Univ. of Kansas, Lawrence, Kansas. **Intermountain Industries**—W. C. Bauer, Intermountain Chem. Corp., Box 872, Green River, Wyoming. **High Temperature Chemical Kinetics and Transport Phenomena**—W. R. Marshall, Univ. of Wisconsin, Madison, Wis. **Dry Classification of Solids**—D. W. Oakley, Metal and Thermit Corp., 100 Park Ave., New York, N.Y. **Safety in Air and Ammonia Plants**—N. H. Walton, Atlantic Refining, 3144 Passyunk Ave., Philadelphia 1, Pa. **Improved Utilization of Technical Manpower**—J. F. Cheely, Ethyl Corp., Box 341, Baton Rouge, La. **Petroleum Refining**—L. W. Russum, Standard Oil Co. (Indiana), Whiting, Ind. **Hydrometallurgy-Chemistry of Solvent Extraction**—G. H. Beyer, Chem. Eng. Dept., U. of Mo., Columbia, Mo. **Alternate Energy Sources**—H. F. Nolting, Std. Oil Co. (Ind.), 2400 New York Ave., Whiting, Ind.
Deadline for papers, May 21, 1958.

• Cincinnati, Ohio, December 7-10, 1958. Netherland Plaza Hotel. **A.I.Ch.E. Annual Meeting.** Genl. Mtg. Chmn.: T. B. Wiehe, Schenley International. Tech. Prog. Chmn.: A. C. Brown, Emery Industries, Inc. June & Long Sts., Ivorydale, Ohio. **Pollution Control by In-Plant Measures**—C. Fred Gurnham, Dept. of Chem. Eng., Michigan State U., East Lansing, Michigan. **A.I.Ch.E. Research on Bubble Cap Tray Efficiency**—W. C. Schreiner, M. W. Kellogg Co., 711 Third Ave., New York 17, N. Y. **High-Speed and Time-Lapse Photography in Chemical Engineering**—J. W. Westwater, William Albert Noyes Laboratory, Univ. of Illinois, Urbana, Ill. **Kinetics & Rate Processes**—H. E. Hoelscher, Dept. of Chem. Eng., John Hopkins Univ., Baltimore 18, Md. **Reprocessing of Fluid Reactor Fuels**—O. E. Dwyer, Chem. Eng. Div., Brookhaven National Laboratory, Upton, L.I., N.Y. **The Application of Computers to Heat and Mass Transfer Problems**—J. M. Smith, Northwestern Univ., Evanston, Ill. **Low Temperature Processing**—C. McKinley, Air Products, Inc., Allentown, Pa. **Scale-up from Pilot Plant to Plant**—D. B. Coghlan, Foote Research and Development Laboratories, Berwyn, Pa., R. A. Schulze, DuPont Chambers Works, Jackson Labs., Penns Grove, N. J. **Guideposts in Long Range Planning**—H. E. Wessel, Virginia-Carolina Chemical Corp., 401 Main St., Richmond, Va. **Processing of Irradiated Fuels—A Challenge for the Future**—J. L. Schwennesen, A.E.C., P.O. Box 1221, Idaho Falls, Idaho. **Spray Mechanisms**—J. F. Tourtellotte, Swenson Evaporator Co., 18505 James Couzens Highway, Detroit, Mich. **Polyisoprene Potentialities**—C. C. Winding, Cornell Univ., Ithaca, N.Y. **Air-Cooled Heat Exchange**—W. W. Akers, Dept. of Chem. Eng., Rice Institute, Houston Texas. **Education in Process Control**—T. J. Williams, Monsanto Chem. Co., 1700 S. Second St., St. Louis 4, Mo. **General Papers**—W. M. Licht, Dept. of Chem. Eng., Univ. of Cincinnati, Cinn., Ohio.
Deadline for papers: August 7, 1958.

(*Continued on page* 148)

New Bulletin 18RG describes SK's line of "Safeguard" Rotameters and gives detailed instructions for liquid and gas sizing. A special sheet lists fluids for which PVC is recommended. Send for your copy.

SK "Safeguard" Rotameters with Polyvinyl Chloride (PVC) end fittings are now available for measuring the flow of hydrochloric acid, sulphuric acid, and the many other chemicals for which PVC is recommended. As a matter of fact, these new Rotameters are already being used for corrosive fluid service with excellent results.

Two facts regarding this new PVC "Safeguard" Rotameter are of particular importance.

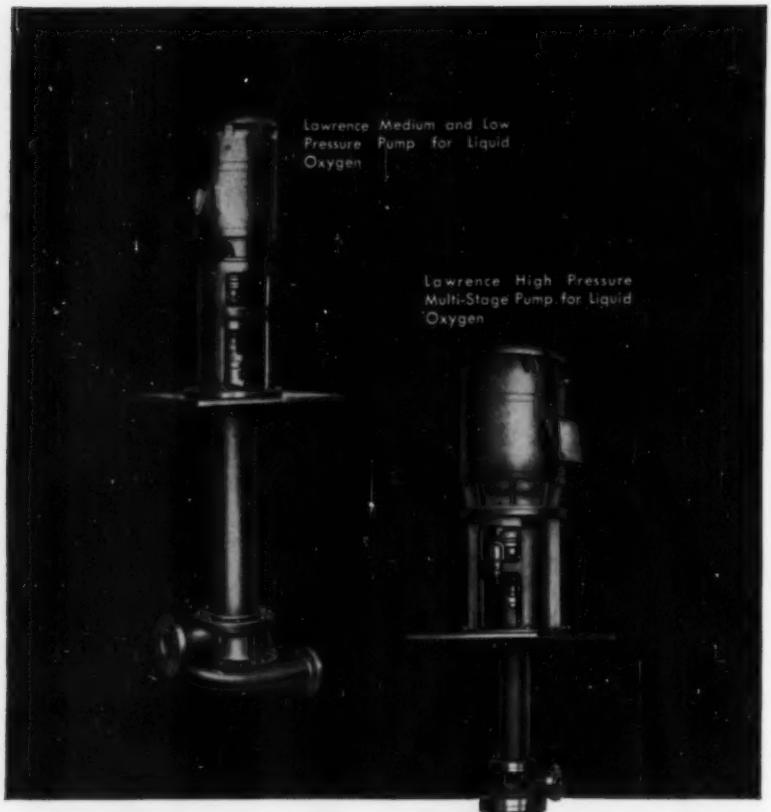
First, this instrument provides a Rotameter with chemical resistant end fittings and rotor at much less cost than a similar instrument with these components made of other special corrosion resistant materials.

Second, the Fig. 18275 "PVC" Rotameter incorporates all of the features of the SK "Safeguard" line—one piece fabricated steel case, tube and rotor versatility, heavy safety glass windows, adaptability to panel mounting and to electric or pneumatic transmission for remote recording and controlling of fluid flow, and others.

Schutte and Koerting COMPANY

INSTRUMENT DIVISION

2245 STATE ROAD, CORNWELLS HEIGHTS, BUCKS COUNTY, PA.



PUMPS

to handle LIQUID OXYGEN *and other* LIQUEFIED GASES

Lawrence Pumps Inc. has developed a special line of pumps for handling liquid oxygen, liquid nitrogen and other gases which can be liquified only at very low temperatures.

Because of the abnormal behavior of materials and liquids at extreme low temperature several of the following features are incorporated in these pumps:

1. Vertical top suction construction to prevent gas binding when the NPSH drops below the safe level, due either to drop in suction pressure, or rise in temperature of the liquid.
2. The packing box does not come in contact with the liquid, only with the blanket of gas in the pipe column.
3. The packing box is fitted with a mechanical seal which has been developed especially for this exacting service.
4. The design has been carefully developed and the materials selected to eliminate any troubles due to differences in expansion and to prevent galling between running parts.

Write for bulletin 203-7

LAWRENCE PUMPS INC.
371 Market Street, Lawrence, Mass.

■ 1958 MEETINGS—NON-A.I.Ch.E.

• **Brussels, Belgium, May 28-29, 1958, and Frankfurt am Main, West Germany, May 31-June 8, 1958. ACHEMA Exhibition:** More than 820 exhibitors from 13 countries will fill 14 exhibition halls. **ACHEMA Congress:** Lecture series, films, plus technical group sessions. **European Federation of Chem. Eng. Congress:** will include sessions on Works and Matls Techniques, Planning, etc. **European Federation of Corrosion Congress:** Nature of corros. and protective measures.

• London (Olympia), England, June 18-28, 1958. **Chemical and Petroleum Exhibition,** sponsored by British Chemical Plant Manufacturers Association and Council of British Manufacturers of Petroleum Equipment. Symposium on **The Organization of Chemical Engineering Projects,** organized by the Institution of Chemical Engineers and the Institute of Petroleum (4 sessions).

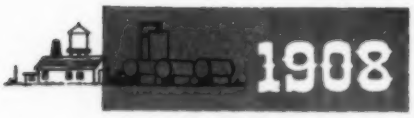
• Geneva, Switzerland, Sept. 1-13, 1958. **Second International Conference on the Peaceful Uses of Atomic Energy.**

■ 1959 MEETINGS—A.I.Ch.E.

• Atlantic City, N.J., March 16-20, 1959. **A.I.Ch.E. National Meeting.** Chalfonte Haddon Hall Hotel. Gen. Chmn.: J. D. Stett, Dept. of Mech. Eng., Rutgers Univ., New Brunswick, N. J. **Recent Advances in Polymeric Materials of Construction**—M. F. Cigliotti, Monsanto Chem. Co., Plastics Div., Springfield, Mass. **Business and Technology**—K. Watson, Consultant, P.O. Box 181, Lake Zurich, Ill. **Laboratory and Pilot Plant Techniques**—G. W. Blum, Goodyear Tire and Rubber Co., Akron, Ohio. **Rocket Propulsion**—J. L. Franklin, 3710 Harrison N. W., Washington 15, D.C. **General Papers** (2 sessions)—J. Hoffe, Newark College of Engineering, 367 High St., Newark 2, N.J. and E. C. Johnson, Dept. of Chem. Eng., Princeton Univ., Princeton, N.J. **Computer Control of Processing Units**—D. M. Boyd, Universal Oil Prod., 30 Algonquin Rd., Des Plains, Ill. **Startup of New Chemical Plants**—M. L. Nadler, DuPont, Penns Grove, N. J. **Care and Feeding of Executives**—J. S. Wilson, Heidrick and Struggles, 20 No. Wacker Dr., Chicago 16, Ill.
Deadline for papers: November 16, 1958.

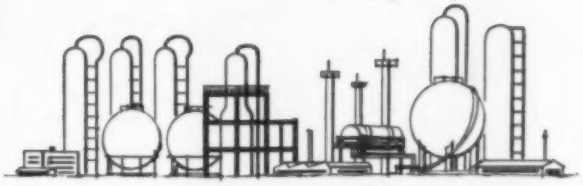
• Kansas City, Missouri, May 17-20, 1959. Hotel Muehlebach. **A.I.Ch.E. National Meeting.** Gen. Chmn: F. C. Fowler, Consulting Chem. Engr., 7515 Troost Ave., Kansas City, Mo. Tech. Prog. Chmn.: Fred Kurata, Chem. Eng. Dept., Univ. of Kansas, Lawrence, Kansas. **Reaction Kinetics**—R. R. White, Dept. of Chem. Eng., Univ. of Michigan, Ann Arbor, Mich. **How to Become a More Proficient Technical Engineer. Heavy Chemicals. Petrochemicals**—G. E. Montes, National Petrochemical Corp., Tuscola, Ill. **International Licensing and Collaboration**—R. Landau, Scientific Design Co., 2 Park Ave., New York, N. Y. **General Papers**—J. O. Maloney, Univ. of Kansas, Lawrence, Kansas. **Non-Equilibrium Fluid Mechanics**—M. J. Rzasa, Cities Service R&D Co., 60 Wall St., New York, N. Y. **Multiphase Flow in Pipes and Annuli**—C. S. Kuhn, Magnolia Petroleum Co., 907 Thomasson Dr., Dallas, Texas. **General Papers**—J. O. Maloney, Chem. Eng. Dept., Univ. of Kansas, Lawrence, Kans.
Deadline of papers: January 17, 1958.

• San Francisco, Calif., December 6-10, 1959. **A.I.Ch.E. Annual Meeting.** Gen. Chmn: Mott Souders, Jr., Shell Development Co., 4560 Horton St., Emeryville 8, Calif. Tech. Prog. Chmn.: C. R. Wilke, Div. of Chem. Eng., Univ. of Calif., Berkeley, Calif. **Process Dynamics**—E. F. Johnson, Dept. of Chem. Eng., Princeton Univ., Princeton, N.J. Deadline for papers: August 6, 1959.



AIChE

1958



this GOLDEN ANNIVERSARY is your GOLDEN OPPORTUNITY!

May 1958 CHEMICAL ENGINEERING PROGRESS will be a spectacular issue commemorating the "Chemical Engineers' Golden Jubilee"

The American Institute of Chemical Engineers' 50th Anniversary marks a major milestone in the progress of the Chemical Process Industries, from the celluloid era to today's rocket fuels. From vital discoveries in basic research, through the entire scope of chemical engineering, A.I.Ch.E. will celebrate fifty fabulous years of achievement.

A salute to the past is only part of the celebration. The main theme of the Jubilee program next June at Philadelphia will be "A Look to the Future." Here is the real significance of May CHEMICAL ENGINEERING PROGRESS for all advertisers—chemical engineers dedicated to the growth and development of all chemical industries.

This is truly a *golden opportunity* for manufacturers to instill both their corporate and their product messages in the minds of responsible chemical engineers—men whose decisions are essential to the purchase and specification of practically all chemicals, equipment, materials and engineering services in the chemical process industries.

Highlights of May C.E.P. include a History of Chemical Engineering and A.I.Ch.E., and a survey of Chemical Engineering Around the World, plus other fascinating features and timely engineering articles. This matchless editorial selection insures intensive readership.

Take full advantage of this unusual opportunity to invest in your company's future in the growing C.P.I. Join the many advertisers who are planning special product progress stories to relate their company growth to the Golden Jubilee of A.I.Ch.E.

The May 1958 issue of C.E.P. will be a big issue—your big opportunity to get big results. Be sure to reserve *adequate* space.

CEP CHEMICAL ENGINEERING PROGRESS

Published for chemical engineers by the
American Institute of Chemical Engineers
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AN INVITATION TO

ALL STUDENT MEMBERS OF THE A. I. Ch. E.

TO ATTEND

THE GOLDEN JUBILEE OF CHEMICAL ENGINEERING

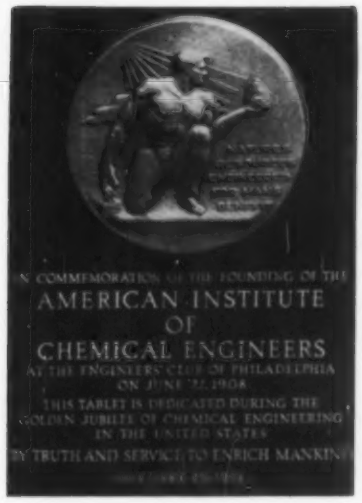
JUNE 22 TO 27, PHILADELPHIA, PA.

ALL STUDENT PROGRAM INCLUDING

LUNCHEON:	As guest of industrial hosts
PRESENTATION OF STUDENT PAPERS:	National contest of Regional Conference winners
BANQUET:	Nationally prominent Speaker, Presentation of cash prizes and awards to National Student paper Contesf Winners

Registration for the full week of the Golden Jubilee, including the all day student program, social activities and technical sessions: $1.00

For further information, write to Local Arrangements Committee General Chairman: William E. Chalfant, The Atlantic Refining Company, Box 8138, Philadelphia 1, Pa.



What Makes A Jubilee ?

At ten o'clock on Monday morning, June 23, festivities that mark A.I.Ch.E.'s jubilee year will begin. The celebration, to be held in Philadelphia, can with justice also be regarded as commemorating the fiftieth year of chemical engineering as a profession.

Program plans are well under way, and the non-technical portion of the festivities are at this point sufficiently definite to be described.

President Holbrook will preside at the keynote session on Monday morning, and C. C. Furnas will be master of ceremonies. His Honor, the Mayor of Philadelphia, will be joined by prominent educators and civic figures in welcoming the Institute and its members and in marking the occasion. Shell Oil's executive vice-president Monroe E. Spaght, noted speaker on affairs of interest to chemical engineers and the chemical industries, will deliver the keynote address.

A second highlight of Monday's activities will be an Awards Session at which Citations, a 50-year Certificate, and several Founder's Certificates will be presented. In addition, Founder's Awards for ". . . outstanding contributions to the chemical engineering profession . . ." will be issued; and the Slogan and Symbol Awards will be presented to the winners of last summer's Medallion Contest.

Main speaker at the Tuesday luncheon will be Augustus B. Kinzel, vice president of Union Carbide, and newly-elected president of the A.I.M.E. ("miners").

The bestowal of honorary degrees on Wednesday morning will take place at the University of Pennsylvania following an invocation by the Chaplain of the U.S. Senate and a brief address by Pennsylvania University's president. The president of Drexel Institute will be announcer at this session; he will introduce representatives of foreign and domestic societies whose greetings will be responded to, on behalf of the A.I.Ch.E. by President Holbrook.

The former president of the British Institution of Chemical Engineers John A. Oriel, of Shell Petroleum, will address Wednesday's luncheon.

And on Wednesday evening, the gala banquet: C. G. Kirkbride will be toastmaster and duPont president Crawford Greenwalt will deliver the evening's major address. Souvenirs will be distributed to mark what promises to be a memorable evening.

Philatelists among our members will be pleased to learn that a commemorative stamp in honor of the jubilee may be issued. In which event cancelling machines for first day covers will be made available.

Thursday's luncheon, to be addressed by a prominent political speaker, will be the final non-technical event of the week.

This is a very inadequate attempt to outline what will doubtless be the outstanding commemorative event in chemical engineering's 50-year history. Certainly the event will prove more satisfying than any description. More news next month—on the technical program—the theme of which will be "A Look to the Future."

HIGHLIGHTS OF TECHNICAL PROGRAM

Theme: A Look to the Future.

Future Trends in the Fundamentals of Chemical Engineering (2 sessions). The Place of Chemical Engineering in the Nuclear Field (1 session). What's Ahead in Kinetics and Reactions (2 sessions). The Changing Field of Unit Operations (4 sessions). Chemical Engineering Education—Undergraduate, Graduate, and Industrial (3 sessions). Materials of Construction in the Future—Metals and Non-Metals (2 sessions). Moving Forward in the Control of Chemical Processes (2 sessions). The Management of Chemical Industries in 1965 (2 sessions). A Look Ahead in the Economics of Manufacturing Chemicals (1 session). The Shape of the Future—Raw Materials, Energy, Capital, Human Resources (1 session).

Montreal—
an opportunity to meet with our northern cousins

E. L. Williams | Du Pont Company of Canada, Montreal, Canada

Sometimes Canada is too close for us to appreciate its chemical engineering advances. At the big, joint A.I.Ch.E.-C.I.C. meeting in Montreal on April 20-23, American chemical engineers will have a golden opportunity to "talk shop" with their Canadian confreres.

The chemical and allied products industry in Canada makes some $1¼ billion worth of products a year, or about 5 per cent of all manufacturing output. About 60 per cent of this is basic chemicals, fertilizers, explosives, primary plastics, synthetic rubber, pharmaceuticals, and coal tar products. Canada's per capita consumption of chemicals is about half that of the U.S., and the country imports more chemical products than it exports.

Most Canadian chemical industries still employ processes developed elsewhere, but this is changing. Canada has laid the foundation of its chemical and allied industries on abundant raw materials and cheap power. But today, chemical engineering has come of age in Canada, important new developments are being originated in increasing numbers by our northern cousins, and meeting them *en masse* at Montreal will provide the American chemical engineer with a great deal of professional eye-opening.

Uranium processing is one field where the Canadian chemical engineers have done a lot of original work. Major Canadian developments have been made in the recovery of uranium from leach liquors, the application of ion exchange techniques to uranium processing, the use of solvent extraction for uranium recovery, the development of an acid pressure leaching process for uranium ores which is expected to find application in the treatment of ores containing sulfidic materials, and many other techniques and applications in the field.

Chalk River, Canada's atomic installation, has the first large-scale heavy water reactor which was, until recently, the world's highest neutron intensity reactor. Chalk River was also the world's first producer of cobalt-60 for radiation processing applications.

Mining, and its concomitant operation of refining, has long been a major Canadian industry employing many chemical engineers. New developments, techniques and applications are numerous in this field in Canada.

Canadian chemical engineers have done considerable original work in the

KNOW YOUR AUTHORS AT MONTREAL

FOR YOUR WALLET

Joint A.I.Ch.E.-C.I.C. International Meeting: Montreal, Quebec, Canada, Mount Royal Hotel, April 20-23.

Registration: begins Sunday, April 20, 1.00 P.M., Ninth floor foyer, Mount Royal.

First Technical Session: 3:00 P.M., Sunday.

Last Technical Sessions: 2:00 P.M., Wednesday.

Habitant Banquet: Tuesday, April 22, 7:00 P.M., Ball room, Mount Royal.

production of heavy water, of wood products and silva chemicals, of petroleum products, and of explosives. It was in Canada that much of the work was done on the development of a process for making cordite and smokeless powder from wood pulp. Significant advances in the manufacture of butadiene by catalytic dehydrogenation of normal butylenes have been made in Canada also.

Canadian chemical engineers are devoting an increasing amount of study to problems of effluent and waste disposal. Classic early work in this area was done in Canada on the control and utilization of metallurgical waste gases

(*Continued on page* 154)

Kohler, Jane, Winmacker
Bagby, Lux, Young
Goodfriend, Bonvallet, Embleton
Carberry, Johanson, Wen
Bartram, Cooper, Spriggs

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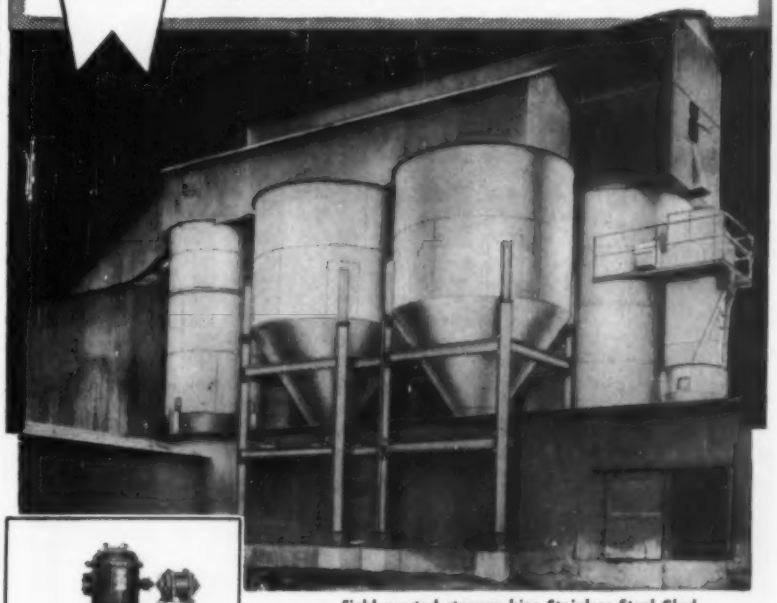

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Jacketed mixing Kettle made of steel

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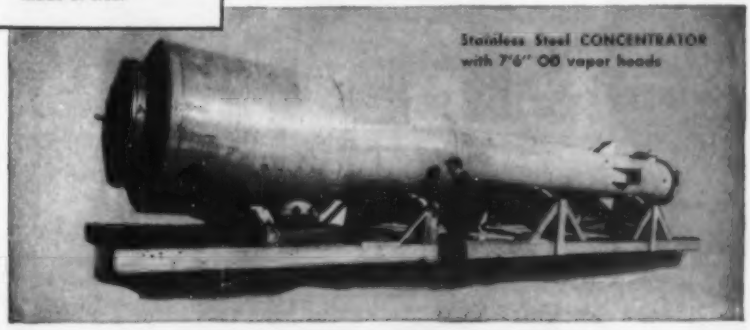
KOVEN equipment in all metals and alloys includes: High pressure vessels built to A.S.M.E. Codes; extractors; mixers; stills; kettles; tanks; stacks; breechings; hot transfer lines; large diameter fabricated piping and plate exhaust ducts; shop and field erected storage tanks; high vacuum testing.



Stainless Steel CONCENTRATOR with 7'6" OD vapor heads

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See Sweet's Catalog File and Chemical Engineering File

80 ft. dia. Clarifying Tank—Field Erected

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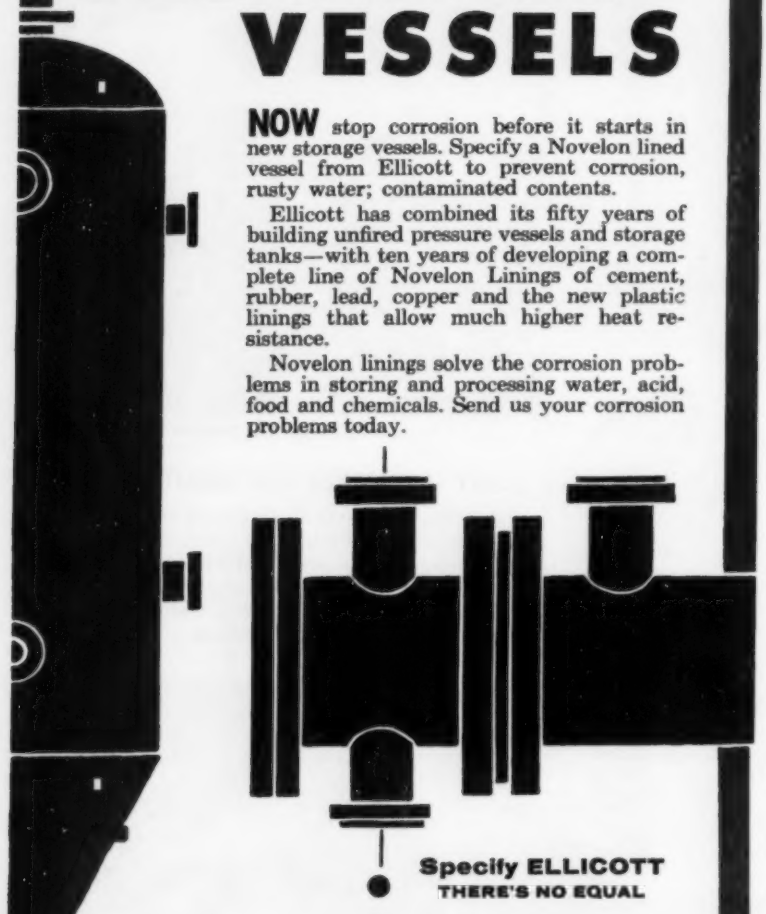
Announcing CORROSION CONTROLLED VESSELS

NOW stop corrosion before it starts in new storage vessels. Specify a Novelon lined vessel from Ellicott to prevent corrosion, rusty water; contaminated contents.

Ellicott has combined its fifty years of building unfired pressure vessels and storage tanks—with ten years of developing a complete line of Novelon Linings of cement, rubber, lead, copper and the new plastic linings that allow much higher heat resistance.

Novelon linings solve the corrosion problems in storing and processing water, acid, food and chemicals. Send us your corrosion problems today.



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MONTREAL—

(*Continued from page* 153)

containng SO_2, and today every chemical and related industry in Canada is actively tackling its problems in this field. In the same general area, Canadian chemical engineers are pioneers in the economical use of waste gases.

From the Rest of the World, Too

Apart from American-Canadian relations and contributions, the Montreal meeting will have a strong international flavor, and the American engineer will have the chance to hear and speak to leaders of the four largest chemical companies in Europe—*the* four largest. These companies are Imperial Chemical Industries Ltd. of Great Britain; Establissements Kuhlmann of France; Farbwerke Hoechst of Germany; and Montecatini of Italy (represented by "isotactic polymer" developer Natta for any engineer in that field who wants to talk shop.) If this is not enough, the Soviet Union is sending two members of its Academy of Sciences in Moscow—one will be an academic leader, and one will be a man from the chemical industry.

Big Technical Program

Designed partly to give engineers not directly concerned with design and construction of chemical engineering plants an understanding of the problems encountered in this area, and some idea of methods of solution, the symposium on *Modern Chemical Engineering Construction Techniques is* also expected to provide new ideas for those who work in the field. Four different phases of engineering, design, and construction will be covered under the chairmanship of Lummus's S. A. Guerrieri: using digital computers to solve certain engineering problems; the use of models in design; heavy plate fabrication techniques for process equipment; and field erection techniques.

J. C. Whitwell's *Statistics in Chemical Engineering* symposium will give the chemical engineer practical statistical methods used for solving some of the common problems encountered in chemical engineering. *Methods* are primary, but each paper will have a proper theoretical background. Technical aspects of the production of uranium, titanium, nickel and copper by hydrometallurgical methods; modern concepts of liquid-solid separation; and corrosion-resistant structural ma-

(*Continued on page* 156)

BEN BUTLER (right), West Coast Production Manager, Borden Company Chemical Division. Left, Bernard Egan, Alaskan Copper & Brass Co., Cooper Alloy distributor for the Pacific Northwest.

BUTLER OF BORDEN CHEMICAL

tells why he buys COOPER ALLOY stainless steel valves

Q. Mr. Butler, why does Borden Company Chemical Division require stainless steel valves?

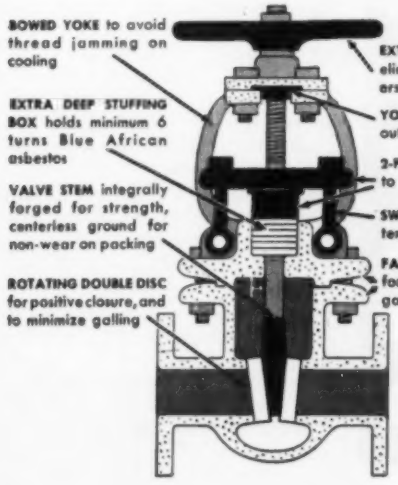
A. In the manufacture of formaldehyde, its derivative resins, and corresponding industrial adhesives only stainless steel can meet our rigid requirements for corrosion, contamination and heat resistance.

Q. What do you consider the most important factor in purchasing valves?

A. The truest measure of a valve is its operating performance. We have never received a complaint on Cooper Alloy valves from our engineers or operating personnel. The extra-large handwheel and unique valve design afford easy operation with positive opening and closing, minimizing maintenance and down time.

Q. What other factors count in choice of valve supplier?

A. Service. The large and complete Cooper Alloy stock at Alaskan Copper affords immediate delivery on stainless steel valves and fittings, as well as pipe. That's a big reason why we buy Cooper Alloy!


BOWED YOKE to avoid thread jamming on cooling
EXTRA DEEP STUFFING BOX holds minimum 6 turns Blue African asbestos
VALVE STEM integrally forged for strength, centerless ground for non-wear on packing
ROTATING DOUBLE DISC for positive closure, and to minimize galling
EXTRA LARGE HANDWHEEL to eliminate need for "persuaders"
YOKE NUT REPLACEABLE without valve disassembly
2-PC. GLAND CONSTRUCTION to prevent scoring of stem
SWINGING EYEBOLTS for maintenance convenience
FAIRED BODY-BONNET FLANGES for equal stress and uniform gasket loading

A VALVE DESIGNED FOR STAINLESS!

The Cooper Alloy valve is not an adaptation of earlier brass and iron patterns. Cooper Alloy, with over 35 years of experience in handling stainless steel, created a valve *designed to be cast in stainless!* **Check the Special Design Features shown at left.**

As the little CA man below is saying: *"You can tell a Cooper Alloy Valve as far as you can see it!"* Write today for *your* copy of our folder "Design Factors In Stainless Steel Valves." The Cooper Alloy distributor near you will be glad to show you the complete line of Cooper Alloy valves *and fittings*, and their advantages. He can serve you promptly from local stocks.

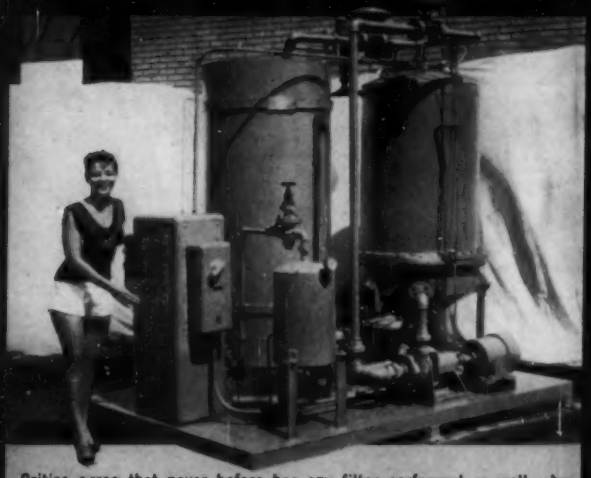
COOPER ALLOY

Corporation • Hillside, New Jersey

VALVE & FITTING DIVISION

THIRTY-FIVE YEARS OF STAINLESS STEEL PIONEERING

CROLL-REYNOLDS
presents
new ClaRite FILTERS
...in an OUTSTANDING
5-STAR performance



Critics agree that never before has any filter performed so well — by eliminating particles down to 1/10 cf a micron with unequaled flow rates. ClaRite filters combine the highest throughput with brilliant clarity.

AND CROLL-REYNOLDS' VERSATILE ClaRite
FILTERS RATE 5-STARS BECAUSE THEY

SAVE MONEY — no need for bags, pads, cloths, cartridges, etc. . . . longer runs are achieved . . . overall cost of production reduced unbelievably.

SAVE LABOR — high velocity backwash eliminates manual disassembly and cleaning once and for all! . . . a few moments of labor time per filter cycle certainly will be a saving for you when compared with your present labor cost.

SAVE TIME — unique wedge opening tubular filter membranes give 3-5 times greater flow with less surface area than other types of filters . . . downtime for cleaning is reduced to a few minutes . . . absolute minimum loss of filtration time assured.

SAVE TROUBLE — permanent membranes and top quality accessories prevent breakdowns, costly delays and loss of expensive product through leakage, clogging or break through of filter media . . . an unequaled simplicity of maintenance achieved in ClaRite design.

IMPROVE YOUR PROCESS and PRODUCT increase flow rate and process efficiency . . . impressively improve filtration clarity, whether your process is small or large, batch or continuous, mild or corrosive.

Standard ClaRite filters, offered according to specific requirements in three types of filter membranes, are available with from 5 to 185 sq. ft. of filtration area, constructed of carbon steel, stainless steel, or lined carbon steel. Special designs available for larger or smaller units or for units constructed of other materials. For additional information, write today.

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SYNTHETIC FIBRES
VITAMINS
WATER
WINES and DISTILLED PRODUCTS

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ENGINEERING CO., INC.

MONTREAL—

(*Continued from page* 154)

terial presented can be readily translated to industrial and pilot plant operation.

The opposing trends of decreasing fossil fuel reserves and increasing demands for energy, are intensifying the search for replenishable energy supplies. J. W. Hodgins *Future Sources of Energy* session will study the present condition of fossil fuels, nuclear power, solar energy, and high-energy chemical fuels. C. J. Marsel's *High Temperature Materials for Jet Propulsion* will study some of the difficult problems of the "thermal thicket or barrier," and some of the solutions being developed—primarily the problem of materials. Another "futuristic" session will be W. M. Campbell's *Chemical Engineering Problems in Heavy Water Reactors*, which is designed to give a detailed picture of this subject to chemical engineers not engaged directly in the field. How to judge when you should make a detailed study of noise problems in your plant is the goal of G. J. Thiessen's *Noise in the Chemical Industry* session.

These are just some of the sessions at Montreal, the rest of the program is equally practical, informative and challenging. Full details in the February *CEP*.

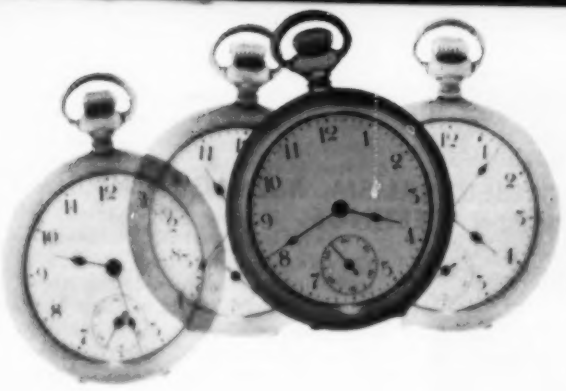
Important Speakers

Three luncheons will keep the chemical engineers well occupied. On Monday the Minister of Industry and Commerce of the Province of Quebec, J. P. Beaulieu, will welcome the American visitors.

Tuesday will have the big International Luncheon chairmanned by A.I.Ch.E. president Holbrook and featuring a major speech by Nobel Prize winner Lester B. Pearson. The international statesman and peacemaker will undoubtedly have a great deal to say about the role of the engineer in the world today.

"Oil and Chemicals—Close Relatives Growing Closer?" will be the subject of W. M. V. Ash, president of Shell Oil Co. of Canada, at the luncheon on Wednesday.

IMPORTANT NEWS! Yes, there will be a banquet as usual on Tuesday night at 7:00 P.M. (with cocktails previously at 6:00 P.M.), but there will be no speaker! Not that the Canadians have anything against banquet speakers, not at all, but this will be Habitant night—a special event where whatever is going to happen has not been revealed. It should be a memorable night. So bring your wife and come to Canada.



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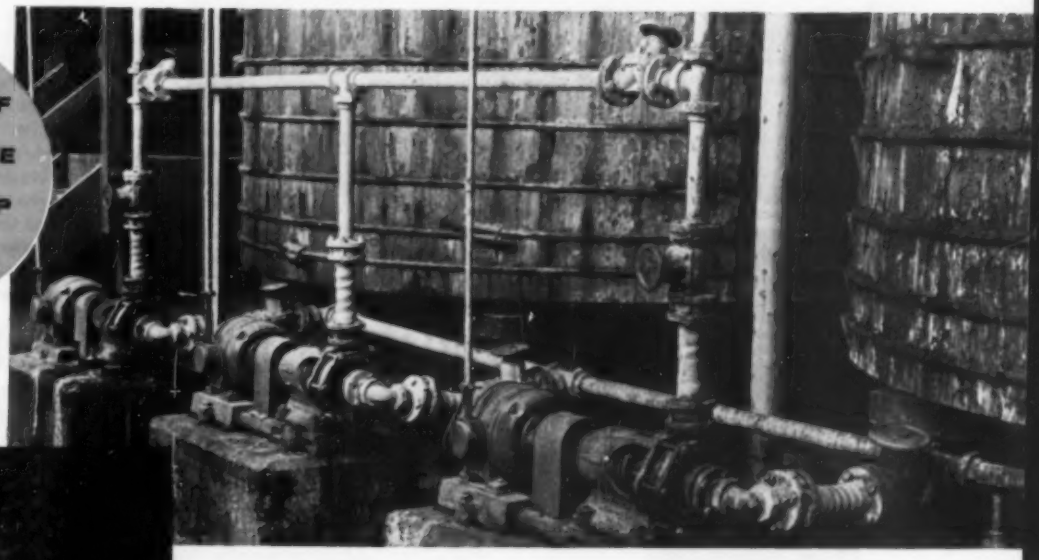

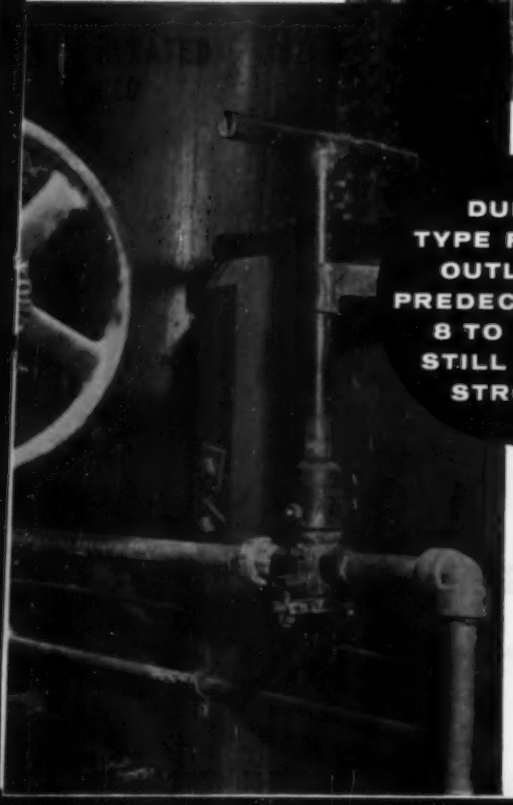

DURCO TYPE F VALVE OUTLASTS PREDECESSORS 8 TO 1 AND STILL GOING STRONG!

Time has proved to American Synthetic Rubber Corporation that no pumps outlast DURCOPUMPS in corrosive service. These DURCOPUMPS, in service since 1943, operate twenty-four hours a day, seven days a week handling sulfuric acid and brine at 140° F. ASRC is contemplating purchasing some new DURCOPUMPS to replace those of another manufacture that failed in a similar service.

Durco Type F valves have also proved to be the answer on a concentrated sulfuric acid line. Where other valves usually froze or failed in less than two weeks, the Durco Type F valve has been in service for five months without even requiring adjustment. Now ASRC is replacing a number of other valves on this line with Durco Type F valves with renewable Teflon sleeve.

DURCO *the mark of dependability in tough chemical service . . . everywhere*

The Duriron Company, Inc.

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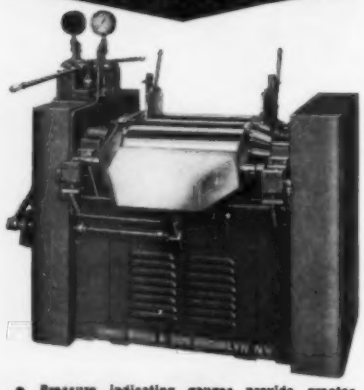
NEW Ross HIGH SPEED
THREE ROLL MILLS WITH—
ONE POINT HYDRAULIC
ROLL ADJUSTMENT



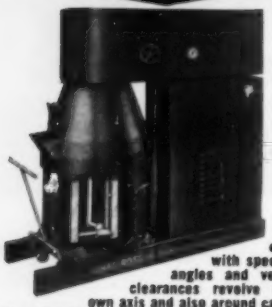
• Pressure indicating gauges provide greater ease in properly setting rolls, and less skill or experience is required by operator.

• Roll pressure settings can be recorded for exact reproduction of material assuring standardization of product.

• Special equalizers assure positive parallelism of roll faces at all times for uniform dispersions and minimum maintenance costs.

• Mills have quick roll release with safety overload feature, and are convertible for either fixed or floating center roll operation. 2½x5, 4½x10, 6x14, 9x24, 12x30, 14x32, and 16x40" sizes.

Production size dispersion type
Change Can Mixers with—
DOUBLE PLANETARY
stirrer action.



• Stirrers with special blade angles and very close clearances revolve on their own axis and also around can, developing 12 intense compressive and shearing actions with each revolution to break down and disperse agglomerates.

• Variable speed for infinite range of stirrer speed control. • Simplified vertical hydraulic lift for greatest ease in cleaning down stirrers. • Non-revolving can is completely enclosed during mixing for safety and to reduce solvent loss. Cans can be jacketed or fitted with slide gate when required. Cans are easily positioned or removed from Mixer. • Extra heavy construction and standard type motor eliminate costly downtime. Oversized motor drives can be provided for kneading and mixing extremely heavy materials. 1, 2, 3, 4, 6, 8, 12, 25, 50, 65, 85, 125 and 150 gallon sizes.

Area of can contacted by stirrers during only one revolution of stirrers around can (2 seconds). Position of stirrers advances 4½" with each successive revolution to sweep entire area and all points on sides of can. Stirrers overlap each other as well as center of can.

Write for further information!

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news from local sections

UNIONISM, PROFESSIONALISM, MANAGEMENT CONCERN OF RECENT MEETINGS

IGY, Process control in CPI also featured. Formation of new clubs booming.

"Automation is partly responsible for some of the present unemployment," was one of the views expressed by Herman Greenberg, Pres. of Western Mass. CIO Industrial Union Council in his address to the **Western Mass.** local A.I.Ch.E. section (*M. Becker*) December meeting. He stated that he felt that automation was necessary for continued industrial progress, but that solutions had to be worked out in specific areas to adjust for the resulting unemployment. Concerning a solution, he indicated that a moratorium on wage increases should be seriously considered by labor groups. In support of this, he pointed out that recent wage increases in the Western Massachusetts area have been offset, to a large extent, by substantial layoffs.

Among other problems of labor, Greenberg mentioned racketeering, reduced incentives, and the training of union representatives. He claimed that it was up to the unions, themselves, to eliminate the first of these; and that the decrease in incentives was due to the leveling of job rates, at the various job levels over the past ten years. He suggested that a solution to this would be for individual local unions to bargain for greater pay differentials. It should be noted in passing that in many instances, management had advocated greater price differentials between levels, but that local unions had insisted on leveling of pay rates. The union's side of the issue "Professionalism versus Unionism for Engineers" was presented to the **New Jersey** section (*R. J. Boyle*) in January by Joseph Amann, President of the Engineers and Scientists of America. The opposite side of the picture was sketched

(*Continued on next page*)

"DELANIUM" GRAPHITE BURST DISCS...
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for the **Oklahoma** section (*E. R. Beck*) in November by J. O. Grantham of Phillips Petroleum in his description of "the Chemical Engineer in Management." In Grantham's opinion, the average citizen looks to the scientific man for the solution of the world's ills; that most experimentation and development is now a team effort; that effective management is required to make the team work efficiently. The engineer must develop his managerial capabilities before he can assume supervisory responsibility. This requires a good technical background and knowledge of human nature. If his job does not offer opportunities for this development, the engineer can learn managerial techniques, and how to deal with people, through active participation in off-the-job activities.

The "Implications of the International Geophysical Year" were broached to the December **Oklahoma** local section (*E. R. Beck*) A.I.Ch.E. meeting by Paul Lyons of Sinclair. He mentioned that the IGY, coordinated by the International Council of Scientific Unions, is a world-wide attempt to learn more about the weather, fuel supply, and sources of energy. His talk was quite complete in that he described *all* of the IGY programs, which include: studies on solar activity and the related investigation of sun spots, and the use of solar energy; the cosmic ray program; atmospheric currents; the ionospheric physics program, of value to electromagnetic communications; the investigation of time . . atomic and as its measurement is affected by gravitation; the earth's gravitational field; the composition of the earth's core; seismology; the antarctic program; and, of course, the rocket program.

The emphasis was on the latter during the **Southern California** (*R. D. Sheeline*) November meeting. Henry L. Richter of Cal. Tech's Jet Propulsion Lab described the history and mechanics of the rocket program. He mentioned that the first true effort to investigate the upper atmosphere was made after WW II by the firing of over 200 V-2's to high altitudes for the purpose of collecting scientific data. However, due to the expense of rockets, and their short time aloft, it was deemed advisable to attempt to position a satellite in an orbit about the earth. It was stated that while an object put into a 100-mile high orbit (at the proper velocity) would return to the earth in less than an hour, because the atmosphere would still offer resistance at that height, a satellite in a 200-mile orbit would remain in space several months, and

(*Continued on page* 160)

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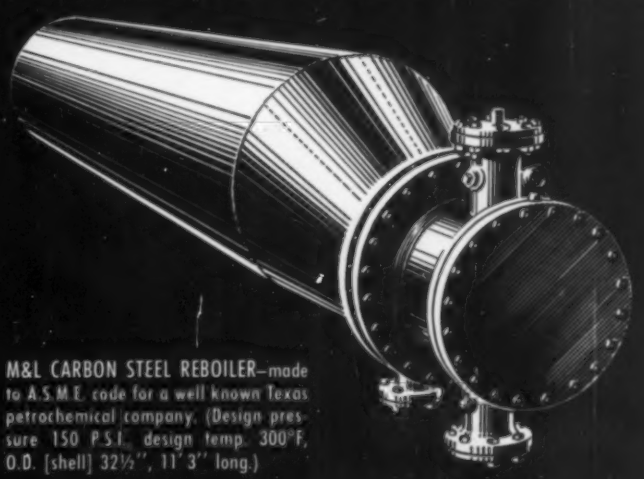

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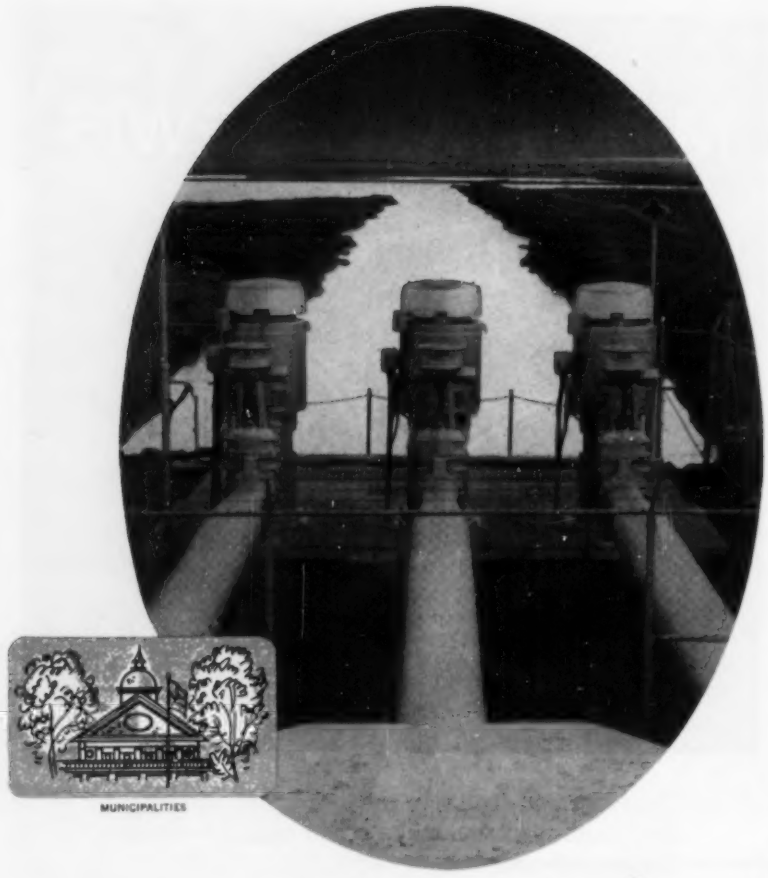

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news from local sections

(*Continued from page* 159)

in a 300-mile orbit several years. By launching from Florida, we are constrained to launch in an easterly direction, so that the first and second stage rockets drop into the ocean. But this allows us to take advantage of an extra 1300 ft./sec. "free" velocity due to the earth's rotation.

Coming back down to earth, some real progress has been made in several areas towards the formation of new local sections. The most recent is the **Chemical Engineers' Club** (presently without a name) at **Longview, Washington.** Its next meeting is scheduled for March 25, and those in that area who may be interested are invited to contact *Robert O. Bethiany*, the temporary chairman, at 1024 Twenty-third Avenue, Longview. Another new starter is the **North Jersey Chemical Engineers' Club,** whose membership just about tripled from a starting group of 42 in December '57 to 120 by February '58. Interested prospective members are advised to contact *Lee A. Parker*, of Clifton, N. J. His phone number is PRescott 7-4600.

The **East Texas Chemical Engineers' Club** (Longview, Texas) is also rocketing along. The December meeting was apprised of "Rocket Engine Applications" by T. M. Davis of Thiokol, see photo. He discussed the design, manufacture, and testing of rocket engines, and compared the merits of solid versus liquid engines.

Demonstration of the burning of Thiokol's solid rocket propellant is given by T. M. Davis, Chief Test Engr. for Thiokol Chem. Corp. at East Texas Chemical Engineers' Club December meeting.

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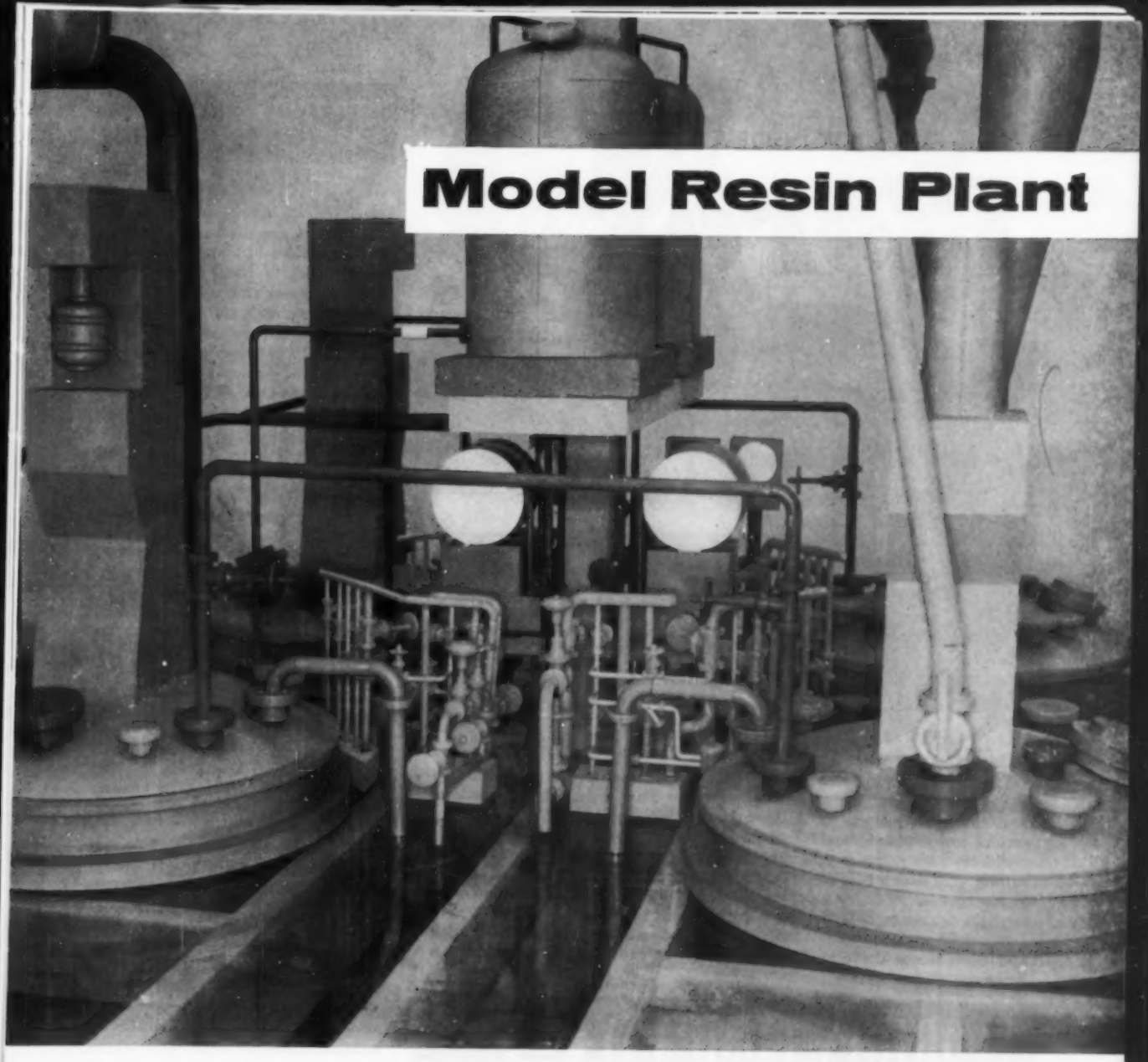

Model Resin Plant

For CIBA Company, Inc. in association with Toms River-Cincinnati Chemical Corporation, The M. W. Kellogg Company is engineering and erecting a new Araldite epoxy resin plant. The detailed model of reactors, valve manifolds, and other equipment pictured above, has long since paid for itself in developing design details and facilitating CIBA's review and approval.

Now an integral part of Kellogg's plant engineering and construction service to industry, the building and application of scale models save time and money in many ways for both customer and contractor. Introduced by Kellogg as a design tool, these models express engineering concepts better; achieve engineering, procurement, and construction goals faster; make the route between plant planning and plant production shorter and surer.

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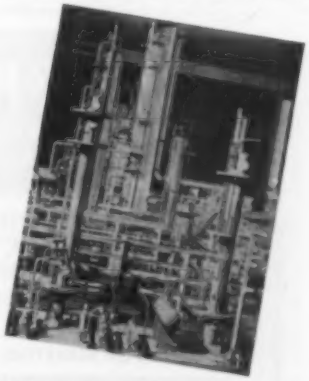

This recent issue of the Kelloggram is devoted entirely to scale models and their use as a tool for better plant design. Many examples, together with construction techniques, are discussed and illustrated in detail.

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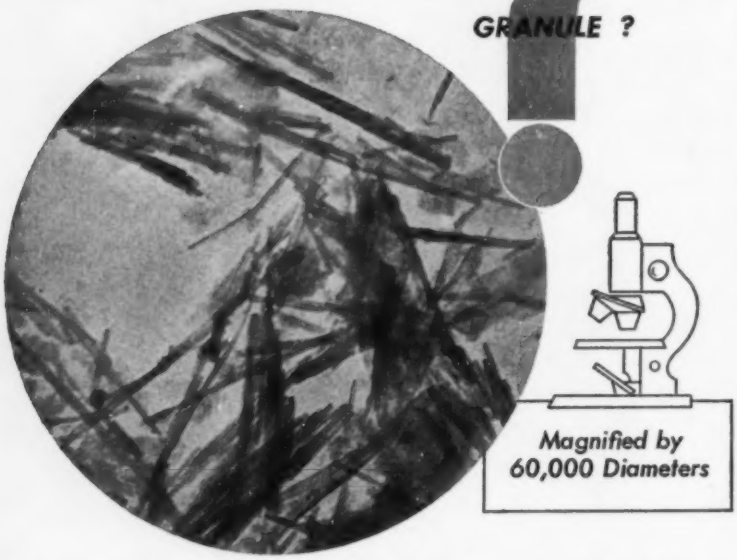

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news from local sections

(*Continued from page 160*)

The **Florida Chemical Engineers' Club** which encompasses an area from the Georgia line to the Bartow-Orlando district, is in its second year, and is applying for Section status. Chemical engineers in that part of the country can get in touch with any one of the following:

Jacksonville area;
E. B. Loyless, St. Regis Paper Co.
Gainesville area;
C. E. Huckaba, University of Florida.
Bartow-Tampa area;
R. E. Tuttle, Jr., International Minerals and Chemicals Corp., Bartow.

The growing interest in process control systems is becoming more apparent. **El Dorado** section (*J. D. Walk*) featured graphical techniques for evaluating control system performance in January, and the making, working, and use of automatic computers in February. The former topic was presented by Robert I. Edelman of Taylor Instrument, who explained that by use of these techniques it is possible to determine optimum controller settings, the effect of altering process time constants, and the effect of changing the control system on performance. These techniques were illustrated using a simple *p*H control problem. The application of automatic digital computers to the specific solution of chemical problems was spelled out by Arthur Rose of Pennsylvania State University. The scope and power of these machines in chemical research and development was demonstrated, along with some of the machines' attendant problems and disadvantages. Process control was also the *pièce de résistance* of the **Sabine Area** (*A. A. Gruber*) February meeting. David M. Boyd of Universal Oil Products told of recent advances in his favorite subject. According to Boyd, it is an interesting aspect of the process control industry that the obvious answer is not always the correct answer. For instance, in the training of new engineers in the field, it is more important to learn to keep the flow of the process *steady* than it is to attempt to maintain a *constant level* in a surge drum. Currently, electronic pulses are being considered for use in control systems, instead of pneumatic pulses. In the mind of most people the magic word "electronics" is synonymous with the

(*Continued on next page*)

ability of being able to do anything at the speed of light. That this is not necessarily true was demonstrated by suitable charts which showed that for the particular application under consideration, the lag time of the system in response to controlling signals was shorter for pneumatic control than for electronic control. In citing another enigma, Boyd described the Graphic Control Panel at Rock Island Refining Co. "Too many people have felt the purpose for building such a panel was to draw a picture on the board." While it is true that the picture, like the fancy perfume bottle, has helped to sell the contents, too many observers have been blinded by the picture and have failed to consider the reasons for designing such a panel, which include: 1) to centralize the control of the whole refinery in one room. 2) the long distances from some of the control points to the board made it necessary to consider localized controllers with transmission of measurement to the board. 3) the small existing control room required consideration of miniature instruments . . . 83 instruments had to be fitted into the space occupied by 25. 4) the use of small instruments permitted controls of each of the refinery units to be grouped as a schematic flow diagram in the available space, instead of the usual grouping of temperatures, pressures, flows, and liquid levels in characterless banks.

"Heat Transfer" from the practical approach, without the use of mathematics or formulas, was the unique presentation of D. Q. Kern to the **Akron** (*F. I. Stannard*) local section in January. His talk was highlighted by numerous examples from his true experiences as a consulting engineer, of failures in new, or established chemical engineering process installations. It was the opinion of Kern that a great number of such failures could be traced to scaling the size of certain unit processes beyond their practical limits; to the failure of the design engineer to recognize the relationship of the controlling factors to the operation of the process; and to the concept that corrective safety factors could be applied directly to processes without regard for operational characteristics.

Also Meeting

Pittsburgh Section (*V. N. Hurd*) at its December meeting heard I. B. Bernstein of Princeton U. discuss Problems of a Controlled Thermonuclear Reactor.

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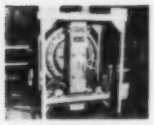

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Objections to the election of any of these candidates from Members and Associate Members will receive careful consideration if received before April 15, 1958, at the office of the Secretary, A.I.Ch.E., 25 West 45th Street, New York 36, N. Y.

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• Packard, Richard D., *Boston, Mass.* Phillips, R. Foy, *Baytown, Tex.*

• Ratterman, Oscar S., Jr., *St. Louis, Mo.* Remnet, Jack, *Inglewood, Calif.* Reynolds, Harold J., Jr., *Somerville, N. J.* Rios, Adolfo, Jr., *Guatemala City, Guatemala.* Roberts, Sanford M., *Brea, Calif.* Robertson, Gerald J., *Chattanooga, Tenn.* Robins, Norman A., *Markham, Ill.* Rosato, Dennis W., *LeRoy, N. Y.*

• Samuelson, L. E., Jr., *Pittsburgh, Pa.* Shaievitz, Sidney, *Allentown, Pa.* Sienknecht, Paul J., *Midland, Mich.* Silverman, Avrum, *Philadelphia, Pa.* Simmerman, Harry G., *Manhattan Beach, Calif.* Sindler, Max A., *Wilmington, Del.* Snow, Richard H., *Chicago, Ill.* Straschil, Heinrich K., *New York, N. Y.* Sundra, Richard A., *Cleveland, Ohio.*

• Timpe, Winfried G., *Tarrytown, N. Y.* Trost, Henry J., Jr., *Bethlehem, Pa.*

• Valentine, Ralph S., *San Pablo, Calif.* Vernon, Leon N., *Ponca City, Okla.* Vorhaben, William S., *San Francisco, Calif.*

• Wakefield, Robert A., *Beaumont, Tex.* Wennerstrom, Jerald M., *Port Allegany, Pa.* Whan, Glenn A., *Albuquerque, N. M.* Wicks, Moye, *Bartlesville, Okla.* Williams, James W., *Argo, Ill.* Williams, William F., *Chattanooga, Tenn.* Wood, Benjamin H., Jr., *Texas City, Tex.*

• Yeager, William N., Jr., *Middletown, N. J.*

AFFILIATE

• Bordner, Gary L., *Windsor, Conn.*
• Frech, David F., *Oak Ridge, Tenn.*
• Torrelio, William, *Whiting, Ind.*

Jointly-owned plant of Monsanto Chemical and Carbometal S.A.I.C. of Argentina will produce vinyl chloride monomer and Opalon, Monsanto's polyvinyl chloride. The new facilities at Mendoza, in Western Argentina, are slated for completion early in 1958. □

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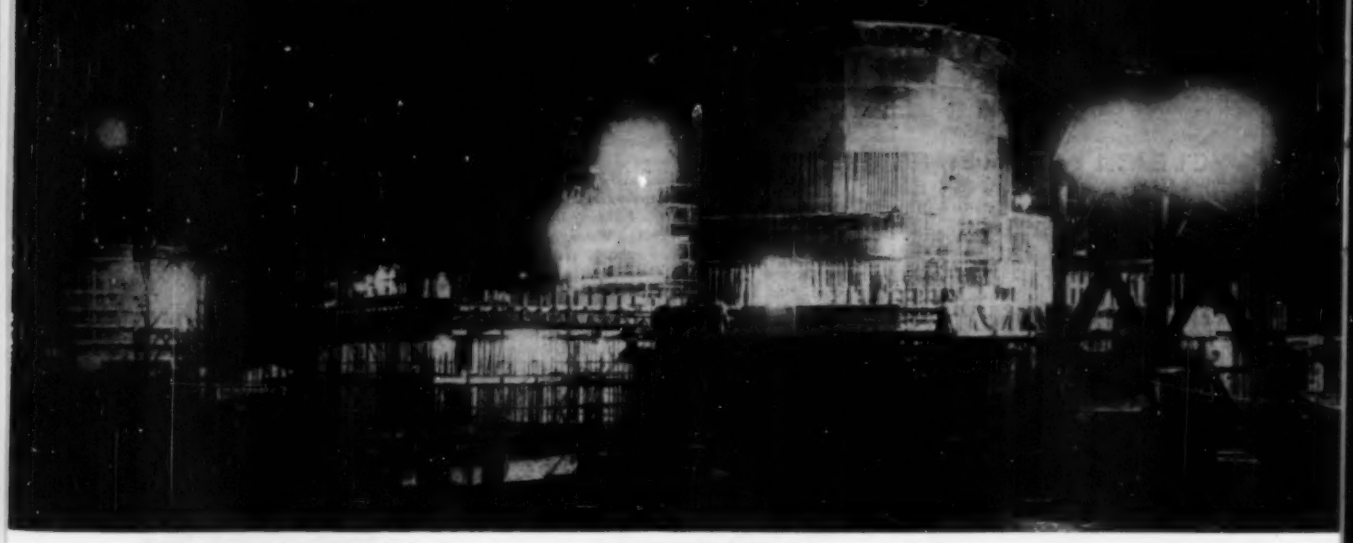
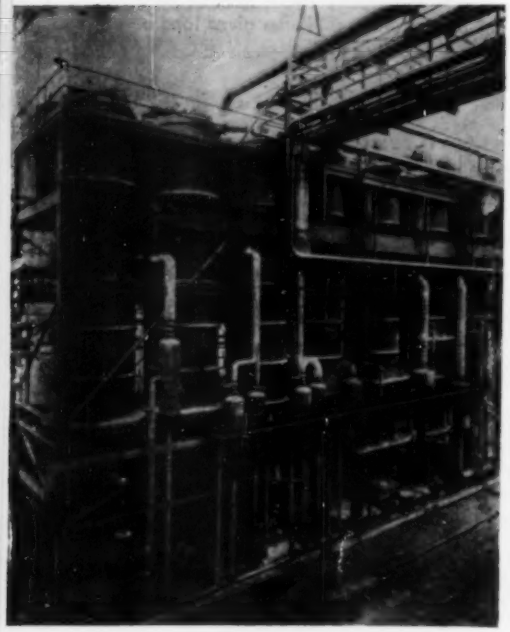


Black Liquor from the daily waste of 400 tons of pulp is concentrated by this huge evaporator at Longview Fibre Co. in Washington. Built by Blaw-Knox, the evaporator processes liquors containing 16 to 55 per cent solids. Unusual design feature is three heat exchangers which reduce hourly steam consumption by 5500 lbs. Total heating surface is 66,500 sq.ft. Overall performance: 6.3 lbs. of water evaporated per pound of steam.

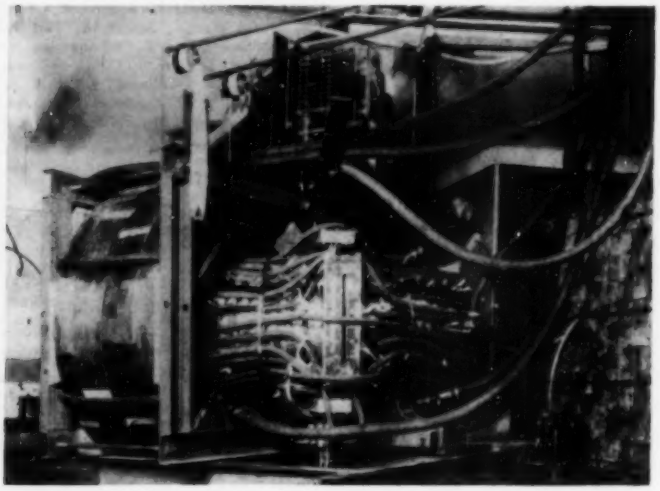


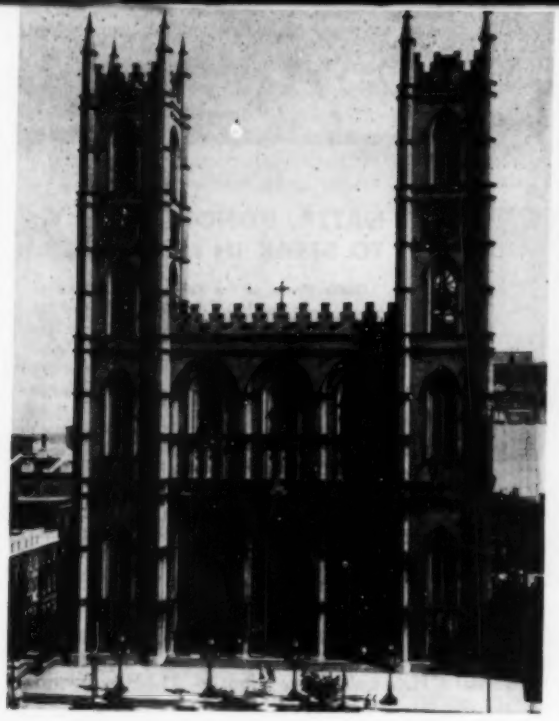
Nocturnal Nucleonics

Work began just a year ago on Britain's nuclear power station at Berkeley, Gloucestershire, England. Scheduled for operation in 1961, it will be one of sixteen such stations to be completed by 1965. Its power output will save Britain between one and two million long tons of coal a year.

Plasma Pincher

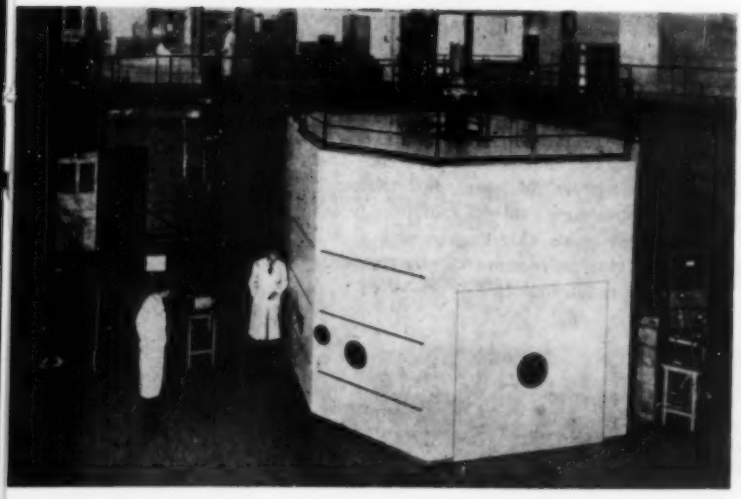
Sceptre II is Britain's Associated Electrical Industries' thermonuclear torus. About one-third the size of ZETA, with which British scientists achieved temperatures of 5- to 6-million degrees C., the Sceptre III has a main diameter of 45" and a 12" bore. Shown here are the heavy primary windings around the torus, and the slit (center of picture) through which discharge is observed.





MONTREAL: Pocket Portfolio

Chemical engineering visitors to the A.I.Ch.E.-C.I.C. Conference in Montreal (April 20-23) will find much to interest them in their off-the-beaten-track wanderings. One of the finest examples of traditional church architecture on the American continent is the Notre Dame Parish Church (upper left), first consecrated in 1829. From the main towers (227 feet in height), the visitor gains a magnificent view of the city and river. Now a museum, the Chateau de Ramezay (left) was erected in 1705 by the French Governor, Claude de Ramezay. After the English conquest, it became the official residence of the English Governors. Visiting hours are 10:00 a.m. to 5:00 p.m. weekdays and 2:00 p.m. to 5:00 p.m. Sundays. Another must in Montreal is McGill University. Above are shown the Chemistry Building (left), the Physics Building (right), both flanking the Physical Sciences Centre.



First Photo

Fueled by enriched U-235 in a water solution, this 50 KW reactor was installed in the Max Planck Institute for Nuclear Physics of the University of Frankfurt in West Germany by Atomics International.

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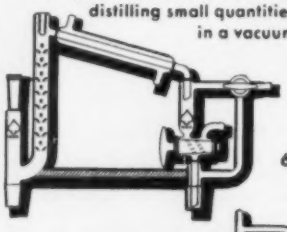

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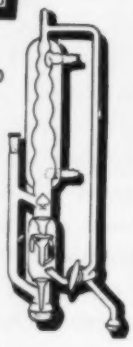

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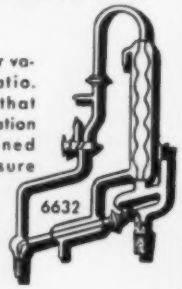

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NATTA, HONORED IN N.Y., TO SPEAK IN MONTREAL

Giulio Natta of the Polytech..ic Institute of Milan, Italy, has been elected a fellow of the New York Academy of Sciences. Under the sponsorship of Montecatini, Natta has developed stereospecific catalysts which permit the synthesis of alpha olefins in such a way as to form regularly-ordered or "isotactic" structures. First practical application of Natta's catalyst discoveries has been commercial production of isotactic polypropylene plastics, started last fall by Montecatini.

Natta will be the spokesman for the Italian chemical industry at a symposium to be held at the A.I.Ch.E.-C.I.C. Conference in Montreal (April 20-23).

Recipient of the 1958 Honor Award of the Commercial Chemical Development Association will be **Bernard H. Jacobson,** vice-president and director of Food Machinery and Chemical. The award, presented annually for outstanding achievement in the field of commercial chemical development, will be given to Jacobson for pioneering work in development of plasticizers of vinyl resins and related products.

New members of the staff of the Productol Co., Santa Fe Springs, Calif., are **Charles H. Braithwaite,** who becomes director of research and development, and **William Martin,** who also joins the Research and Development Department. Braithwaite was formerly associated with Food Machinery and Chemical Corp. at Baltimore, and Martin with Harbor Plywood, Aberdeen, Wash.

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New vice-presidents in the Nitrogen Division, Allied Chemical & Dye, are **George B. Meredith,** in charge of production, and **Frank O. Agel,** in charge of development. Meredith has been director of production, supervising operation of the division's four plants, while Agel has been director of development.

Recent promotions at Stone & Webster Engineering Corp. include: **Theodore E. Casselman, Jr.,** to assistant engineering manager; **Norman L. Foskett** to chief engineer of the chemical division; and **Stanley B. Zdonik** to chief process engineer.

Raymond W. Hess, coordinator of pollution research and control, National Aniline Division, Allied Chemical & Dye, has been presented with the Arthur Sidney Bedell Award of the Federation of Sewage and Industrial Wastes Associations.

New appointments at Esso Research and Engineering, Linden, N. J., include **James D. Bushnell** as head of the fuels and treating section, and **Robert P. Cahn** as engineering associate, both in the company's Planning Engineering Division.

GAVEL SWITCH

Augustus B. Kinzel left), newly-installed president of the American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME) receives the gavel from his predecessor, Grover J. Holt (right) at the recent AIME national convention in New York. Kinsel, who has made advanced contributions in the fields of metallurgy and atomic energy, is vice-president of Union Carbide Corp.; Holt is assistant to the president of Cleveland-Cliffs Iron Co. In his inaugural address, Kinsel called for "more stress on quality in our new engineers and scientists, and less on quantity." He urged the establishment of special secondary schools for the more gifted among our students.

William T. Griffiths has been elected president of Anders-Lykens Corp., wholly-owned subsidiary of Milton Roy Co. **Robert T. Sheen,** president and chairman of the board of Milton Roy, will serve as board chairman for Anders-Lykens.

(*Continued on page* 170)

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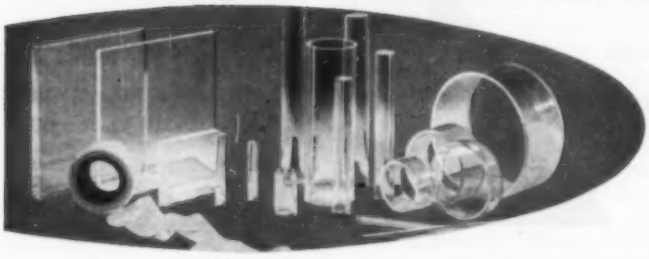

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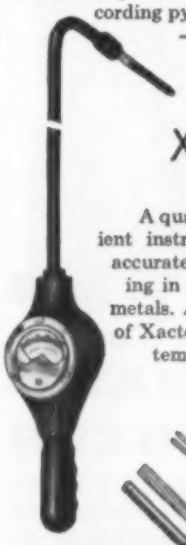

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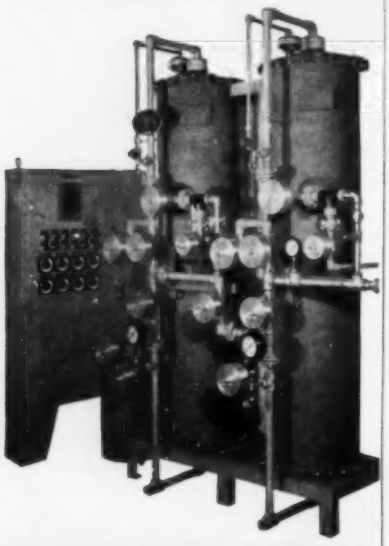

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people
(management & technology)

(*Continued from page* 169)

Charles H. Stockman named manager, research operating, at B. F. Goodrich's Research Center, Brecksville, Ohio. Stockman joined the Research Center staff in 1950 as a chemical engineer. From September, 1953, until September, 1954 Stockman was on loan to the AEC and served at Argonne National Laboratories.

Stockman

Barnett F. Dodge, head of the Yale Department of Chemical Engineering, spent from October to December, 1957, at the Universidad Centrale de Venezuela, Caracas, where he gave two courses—one in elementary unit operations, the other in problems in applied thermodynamics. Both courses were given in Spanish. This spring, Dodge will lecture at the University of Lille, France, for four months on a Fulbright appointment.

Elton R. Beverly named group supervising engineer at the Hopewell, Va., plant of Allied Chemical & Dye, National Aniline Division. Also in the National Aniline Division, **Stanley P. Anderson** becomes group engineer, vat colors, of the Buffalo, N. Y. plant.

Mathieson Alabama Chemical, subsidiary of Olin Mathieson, appoints **George F. Comer** as plant manager at McIntosh, Ala. Since 1953 Comer has been assistant to the manager of the operations department of Olin Mathieson's Industrial Chemicals Division in Baltimore, Md.

New director of purchases and traffic at Callery Chemical is **Leo A. O'Hearn,** formerly a technical buyer for Westinghouse Electric, Oscar Mayer & Co., and B. F. Goodrich.

Kohlins

Blaw-Knox appoints **William D. Kohlins** as general manager of its Buflovak Division, Buffalo, N. Y. Kohlins has been division manager since 1956.

(*Continued on next page*)

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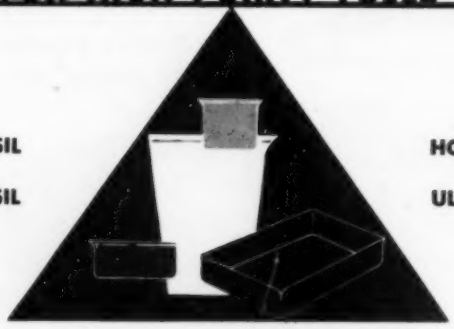

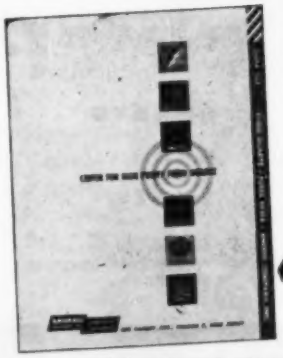

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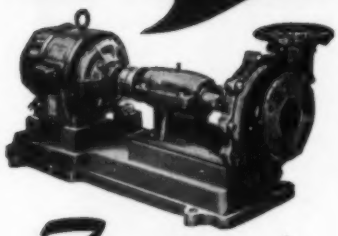

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Pump casings are vertically split for easy accessibility. Mounted on a swivel to permit placing discharge in any desirable position. Pump openings, both suction and discharge, flanged to permit easier connection and disconnecting to joints. One-piece impellers, securely attached to shaft by stout key and lock nut, or threaded, give long service. Pump bearings mounted in sturdy frame horizontally split for easier accessibility. Extra long stuffing box provides for oversize stuffing. Mechanical seal also available for minimum leakage. Pump coupling flexible for direct connection to drivers or can be arranged for belt drive. Pump speed, pump openings, etc. are selected to suit your particular requirements.

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Coons

Edward A. Coons, previously general manager of Armour Chemical Division, has been made general manager of Acheson Dispersed Pigments Co., Philadelphia.

Sheldon K. Friedlander, assistant professor of chemical engineering at John Hopkins University, recently spent three weeks at the Universidad de Oriente, Santiago de Cuba. Friedlander acted as an advisor on the establishment of a chemical engineering curriculum and laboratory.

Two new staff positions have been created in the Research, Patent, and Engineering Departments of Sun Oil Co., Philadelphia: **John L. Olsen** has been named assistant director and **J. Harold Perrine** administrative manager. Also at Sun Oil, **Richard Fleming,** formerly a section chief in the Process Development Division at Sun's Marcus Hook refinery, has been transferred to Olsen's new group.

Arthur D. Little, Inc., announces appointment of **Austin W. Fisher, Jr.,** as manager of business development for their Research and Development Division. Fisher formerly headed the firm's process engineering department.

Recent promotions and appointments at Monsanto Chemical include: **Seaton L. Hunter** to assistant research director in the research department of the Plastics Division, Texas City; **Hans G. Schleicher** to resident project manager in the research department of the Plastics Division, Dayton, Ohio; and **William F. Zimmermann** to manufacturing superintendent, Plastics Division, Texas City.

Alfred C. Nestle of the Texas Company's Bellaire laboratories, and Victor J. Tronolone are co-patentees of a recently issued patent, U. S. 2,811,488, assigned to the Texas Co. and entitled "Lost Circulation."

The National Academy of Sciences, National Research Council, announces the appointment of **Ernest H. Volwiler** as Chairman designate of the Academy-Research Council's Division of Chemistry and Chemical Technology. Volwiler is president and general manager of Abbott Laboratories.

Volwiler

(*Continued on page* 172)

NEW CHEMINEER AGITATOR KIT CONTROLS MIXING VARIABLES

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people
(management & technology)

(*Continued from page* 171)

Services in research programming and administration, the application of science and technology to industry, and in problems of business organization will be offered to industry by a new company, Clyde Williams & Co., headed by **Clyde Williams,** former president of Battelle Institute. The new firm will be headquartered in Columbus, Ohio.

Hinds

Horace Hinds, Jr., has set up his own firm, Process & Air Engineering, in San Martin, Calif. Hinds recently resigned from Basic Vegetable Products, Inc., of Vacaville, Calif.

New vice-presidents at Wyatt C. Hedrick Engineering Corp., Houston, Texas, are **E. D. Redding** and **R. M. Fitzgerald, Jr.** Redding will head

Redding

Fitzgerald

Shackelford

the chemical engineering division, and Fitzgerald the project engineering division of the company. Chief development engineer will be **J. W. Shackelford.**

George B. Hughey, process control superintendent at Chemstrand Corp.'s Pensacola, Fla., nylon plant, has been selected to attend the 19th Southwest Executive Development Program at the University of Houston. Hughey joined Chemstrand in 1954 after holding research positions with Merck and with West Virginia Pulp and Paper.

Parker S. Dunn, vice-president, manufacturing, of American Potash & Chemical, has been elected to the company's board of directors. Prior to joining AP&CC, Dunn was with Potash Corp. of America at Carlsbad, N. M., for 10 years.

Dunn

(*Continued on page* 174)

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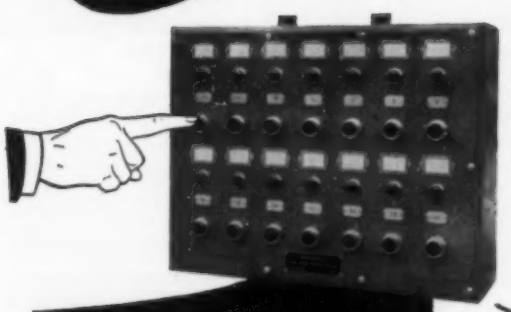
FOR DISTRIBUTION OF DRY BULK MATERIALS



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CAN BE CUSTOM-BUILT IN ALL SIZES TO FIT YOUR PLANT NEEDS

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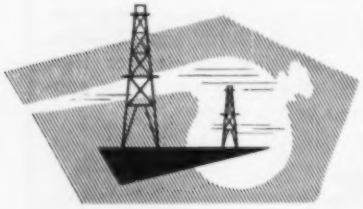

An outstanding development in British industry in the last twenty years has been the expansion of the Petroleum refining and Chemical Industries. The Chemical and Petroleum Engineering Exhibition—the first of its kind—will present dramatic evidence of the tremendous achievements that have been made.

At Stand after Stand, contractors, designers and specialists in every branch of British chemical and petroleum engineering will have something to show of vital interest.

The Exhibition will also include a conference on "The Organisation of Chemical Engineering Projects" arranged by The Institution of Chemical Engineers and The Institute of Petroleum; and films will show how the Chemical Plant and Petroleum Equipment Industries have helped in the development of their consumer industries.

A visit to this Exhibition is a MUST to all concerned in chemical and petroleum projects and to everyone whose industry is in any way influenced by such projects.

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(*Continued from page* 172)

Dewey I. Dykstra named branch chief in the Pilot Plants Division, Army Corps Biological Warfare Laboratories, at Fort Detrick, Frederick, Md. Dykstra has had fourteen years of service with the Army Chemical Corps.

New staff members of the Research and Development Department, Pittsburgh Coke & Chemical, are **Edgar I. Crowley** and **John R. Weinert.**

Schneider

Gilbert G. Schneider will head the sales department for Doyle-Turbulaire scrubbers, new product line of Western Precipitation Corp. Schneider joined Western Precipitation's staff in 1951 as a test engineer.

John W. Benedict appointed sales manager for Girdler catalysts in the Chemical Products Division of National Cylinder Gas Co. Headquartered in Louisville, Benedict will have charge of an expanded sales program in the field of specialty catalysts to the chemical, plastics, petroleum, and food industries.

Benedict

Two new product manager posts have been set up by Jefferson Chemical: **Joseph K. Goerner** will be manager, specialty products, and **D. L. Griswold** will be manager, glycol products.

John H. Sanders becomes regional sales manager for the Chemical Division of Eastman Chemical Products. Sanders will be in charge of those areas served by the division's Cleveland, Cincinnati, and Greensboro, N. C. offices, plus other areas of the South and Southeast.

Saunders

(*Necrology on page* 178)

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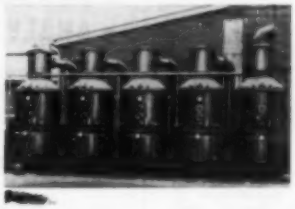
Creates a

MULTIPLE EFFECT EVAPORATOR

Used for preliminary processing of raw sugar



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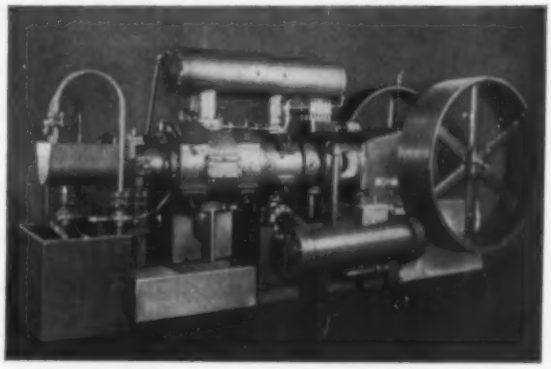

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(*Continued on page* 178)

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(*Continued from page 177*)

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Necrology

David E. Pierce, 66, director of manufacturing control, Diamond Alkali. Pierce was an active member of A.I.Ch.E. for thirty-five years and served as director for the years 1944, 1945, and 1946.

V. A. Kalichevsky, 62, chemical engineer, Magnolia Petroleum, Beaumont, Texas.

J. Neal Addoms, 37, assistant director of the Chemical Engineering Department, Atlas Powder Co., Wilmington, Delaware. Addoms, who joined Atlas Powder in 1953, had been assistant professor of chemical engineering at MIT. He was the author of many technical papers, particularly in the field of heat transfer, in which he was a recognized expert. He was a member of the committee on formation of the Heat Transfer Division of A.I.Ch.E., and was instrumental in organizing and carrying through the First National Conference on Heat Transfer held in State College, Pa., in August, 1957, under the auspices of A.I.Ch.E. and A.S.M.E.

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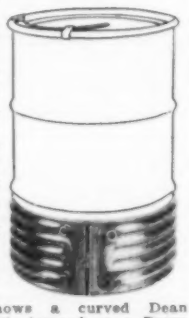

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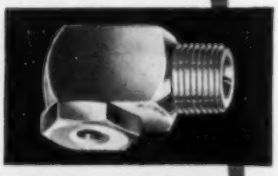

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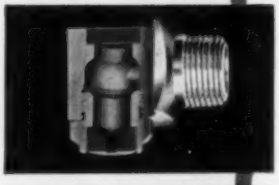

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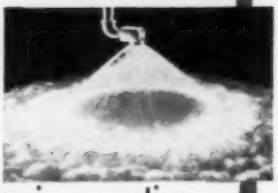

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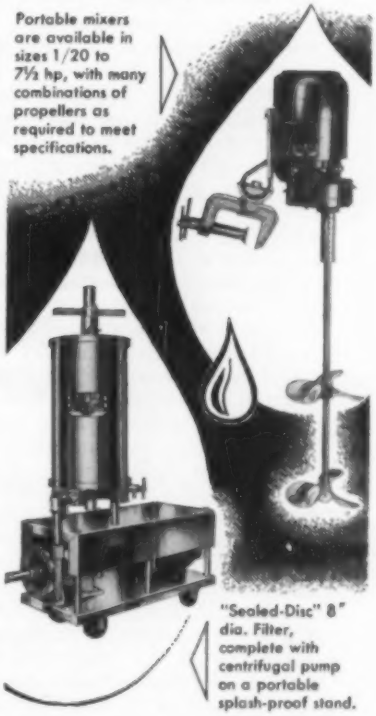
Easily moved from job to job, this versatile equipment eliminates the need for numerous, costly fixed installations. Now is the time to prove this in your plant!

Portable mixers are available in sizes 1/20 to 7½ hp, with many combinations of propellers as required to meet specifications.



"Sealed-Disc" 8" dia. Filter, complete with centrifugal pump on a portable splash-proof stand.

DEPEND ON ADVICE FROM ALSOP

- Liquid Filtration
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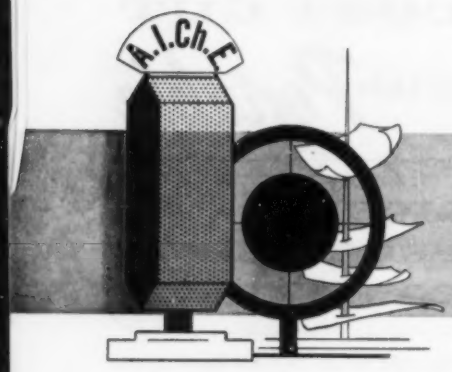
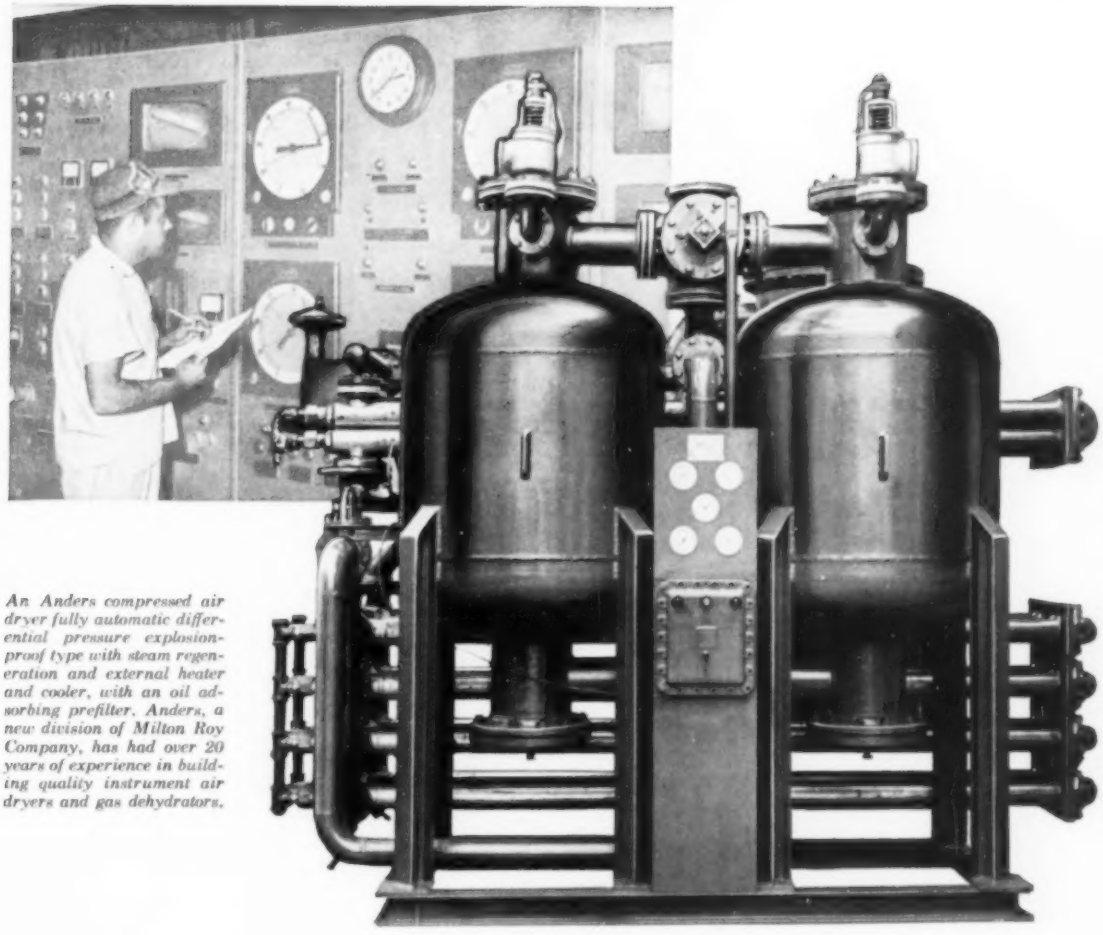


NEWS and NOTES from A.I.Ch.E.

Memo to members: This is a reminder to members of A.I.Ch.E. to write in for the new Directory . . . published late last year . . . As is the custom, this is not sent to all membership but only to those who ask for it . . . We expect to publish another one early in 1959 . . . so **changes of address, job, title, etc.,** ought to be reported to headquarters as soon as possible . . . This request is tied to the issuance of directories & to the proper functioning of the information system for members which is now operating . . . When headquarters receives an indication from a member of a major change from one city to another or from one company to another the Directory Department has orders to send a new questionnaire . . . The questionnaire asks for considerable detail on titles, interests, etc., for the purpose of keeping up to date the information on the statistical cards . . . Some of the information, such as year graduated, college, etc., doesn't change . . . titles do, areas of responsibility do, functions do . . . & if A.I.Ch.E. is going to have this modern system function efficiently, members must cooperate . . . It's for their benefit . . . Major problem, however, is the man who quietly rises in his own company without any indication to the Institute of his change in title . . . This difficulty is compounded when a successful man, having risen from beginning chemical engineer to vice-president in charge of engineering or production, has never changed his company position in the records & at the same time has not answered any of the questionnaires that were sent to him . . . Situations of this kind account for titles of individuals being listed incorrectly . . . So if you want a Directory, write . . . tell us of any change in your status or location . . . & please answer the questionnaires when you get them. **Rockets & missiles:** Our Program Committee has pushed ahead in this area . . . B. M. Landis of General Electric Company's Nela Park, Cleveland, plant is at present chairing a June symposium in the field . . . Ben writes that in his opinion the time is ripe in the Institute for a rockets & missiles division & asks those interested in the field to get in touch with him . . . Ben is well aware that before a division of the Institute can be formed there must be great evidence of its ability to survive & of the true interest of the members . . . so much will depend upon the success of the June symposium & the interest it arouses . . . Speaking of divisions, the **Nuclear Engineering Division** will give members interested in the nuclear field four opportunities to present papers . . . In August there is a Heat Transfer Conference . . . in September the Geneva, Switzerland, Conference . . . in December, in Cincinnati, there are two symposia, one on Processing of Irradiated Fuels & the other on Reprocessing of Fluid Reactor Fuels . . . & in March, 1959, at Atlantic City there will be a symposia on Process, Data & Design Methods for Nuclear Fuel Recovery . . . Those interested should write to Charles E. Dryden, Secretary of the Nuclear Engineering Division, at Ohio State University. **Nuclear Standards:** Members should know that we are sponsoring Section Committee N-5 of the A.S.A. Chemical Engineering for the nuclear field . . . The committee Chairman is S. I. Winde of duPont . . . **Nominating Committee for 1958** will be headed by R. P. Dinsmore . . . For the benefit of Local Section chairmen who want to get their suggestions before the Nominating Committee or roll out a petition for their favorite sons, here is the schedule for 1958 . . . The constitution requires that the nominating ballot be received no later than nine weeks prior to the annual meeting . . . A special Council by-law asks that the Nominating Committee bring in its selections at least twenty weeks before the annual meeting so that the candidates may be presented to the members early through **C.E.P.** . . . We hope to have the candidates publicized in the August issue . . . or preferably earlier . . . & the time table is as follows . . . Nominating Committee selections to be finished by the week of July 18 . . . candidates to appear if at all possible in the August issue of **C.E.P.** . . . The very latest date that petitions for candidates may be accepted by the New York office is October 3. . . . A word of advice to any section members who are considering a petition . . . please try to get the candidates' biographical data, picture, etc., into A.I.Ch.E. headquarters no later than July 15, to ensure publication in **C.E.P.**'s August issue. **The New York Section** has recently issued a publication which tells about the requirements for a New York State Professional Engineer's License . . . qualifications for admission to examinations & available review books & courses . . . It is a mimeographed collection which other Local Sections might want to adapt. F.J.V.A.



An Anders compressed air dryer fully automatic differential pressure explosion-proof type with steam regeneration and external heater and cooler, with an oil adsorbing prefilter. Anders, a new division of Milton Roy Company, has had over 20 years of experience in building quality instrument air dryers and gas dehydrators.

Keep your pneumatic controls operating efficiently

. . . WITH ANDERS AIR DRYERS

You can be sure that your pneumatic control instruments will operate at highest efficiency when your air supply is clean and dry. Proper conditioning of your air supply is assured by Anders Instrument Air Dryers . . . continuous units in which the adsorption, reactivation and cooling cycles are entirely automatic, requiring no attention. Semi-automatic and manually regenerated models are also available.

These automatic dryers are:

• built with open, weatherproof or explosion-proof features • available in 24 standard sizes for quick delivery • designed for 3 hour regeneration cycles and up • supplied for steam or electric activation • welded construction according to ASME and ASA Codes

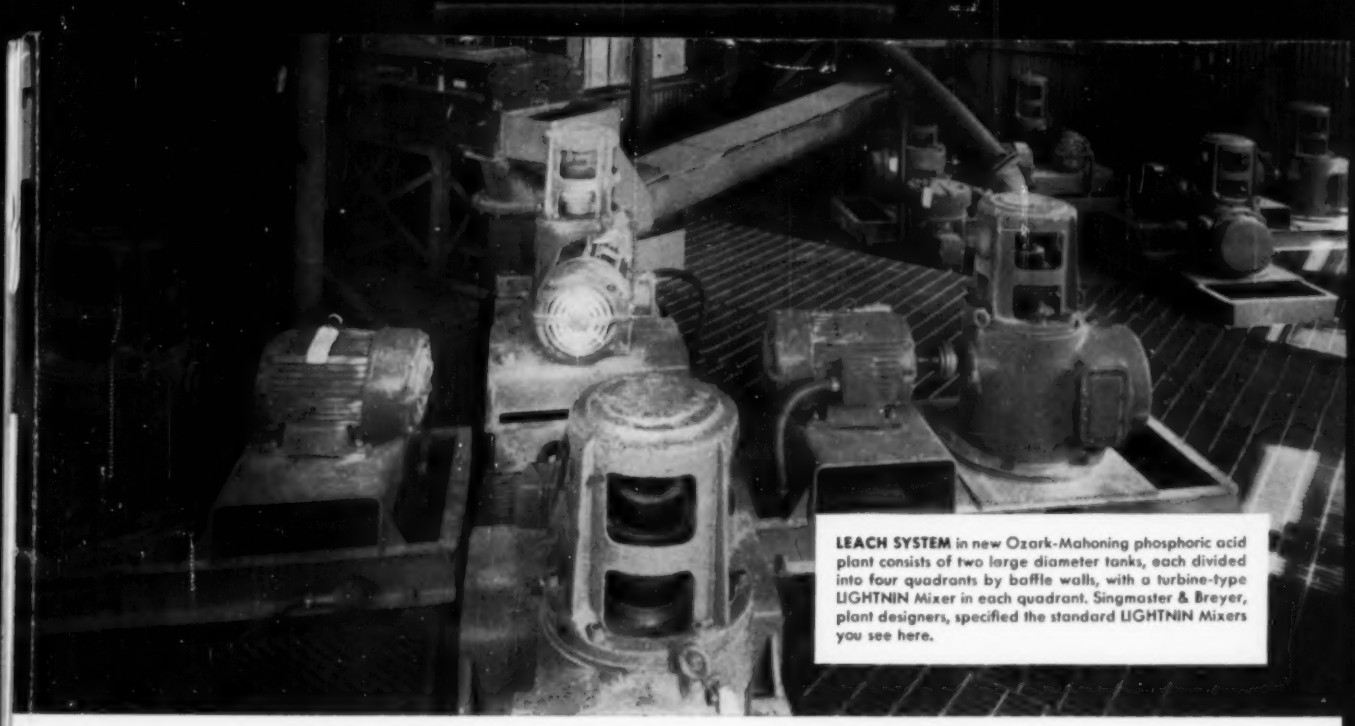
Anders air dryers range in size from a 5 SCFM to an 11,500 SCFM unit. Specially engineered dehydrators for various gases and liquid hydrocarbons are also available . . . in sizes to 100,000 SCFM, at pressures up to 6,000 psi.

For additional information, write for Bulletin 857—"Anders Instrument Air Dryers."

Anders Lykens Corp., a division of MILTON ROY COMPANY, 1300 East Mermaid Lane, Philadelphia 18, Pa., *Engineering Representatives throughout the world.*

CHEMICAL INSTRUMENTATION SYSTEMS

Controlled Volume Pumps • Quantichem Analyzers
Chemical Feed Systems • Anders Air and Gas Dryers



LEACH SYSTEM in new Ozark-Mahoning phosphoric acid plant consists of two large diameter tanks, each divided into four quadrants by baffle walls, with a turbine-type LIGHTNIN Mixer in each quadrant. Singmaster & Breyer, plant designers, specified the standard LIGHTNIN Mixers you see here.

New acid process gives **95% yield** *with good mixing in leach tanks*

More often than you might think, ***good mixing of fluids*** can make the difference between "just average" and superior process results.

That's one reason why LIGHTNIN Mixers were specified for this new wet-process phosphoric acid plant at Ozark-Mahoning Company, Tulsa, Okla. Singmaster & Breyer, New York engineering firm, did the process and equipment design for Ozark-Mahoning Company.

High yield—low cost

Utilizing the Belgian Prayon process, relatively new to this country, the plant consistently yields better than 95% of acid containing 30% P_2O_5. It produces a 32% product from sulfuric acid as weak as 55%.

Leaching temperature is 15-20 degrees cooler than conventional processes—easing the corrosion problem and permitting the use of less costly materials of construction.

The new plant has run without a hitch since the day Ozark-Mahoning operating management pushed the button.

How mixers help

Good mixing does its job in the leach system, where finely ground phosphate rock is slurried with recycled phosphoric acid, then reacted with sulfuric acid to precipitate gypsum.

A LIGHTNIN Mixer in each of eight leach-tank compartments provides the exact balance of fluid flow and turbulence needed for intimate acid contacting and highest extraction values.

The LIGHTNINS also provide complete uniformity and immediate dispersion of reactants, resulting in the growth of large, easily filtered gypsum crystals.

On *your* next project, why take chances on fluid mixing when you can be *sure?* With LIGHTNIN Mixers, you get the security of knowing there's a mixer to match your requirements *exactly*—with replacement parts always quickly available if you ever need them.

Predictable results

You're sure about *results*, too—because your LIGHTNINS are selected on the basis of application and test data unique in industry. Many thousands of pilot runs, plus scientific methods of scale-up, insure predictable mixing results that are unconditionally guaranteed.

For quick, competent help in getting a new process started right, or in making an old process more efficient, call your LIGHTNIN Mixer representative. He's listed in Chemical Engineering Catalog. Or write us direct.

Lightnin® Mixers™

MIXCO fluid mixing specialists

YOU CAN HANDLE any fluid mixing job, in tanks of any size or shape, with LIGHTNIN Mixers. Results are fully predictable; unconditionally guaranteed.

FOR LATEST MIXING INFORMATION and full description of LIGHTNIN Mixers, send for these helpful bulletins:

- ☐ Top or bottom entering; turbine, paddle, and propeller types: 1 to 500 HP (B-102)
- ☐ Top entering; propeller types: ¼ to 3 HP (B-103)
- ☐ Portable: ⅛ to 3 HP (B-108)
- ☐ Side entering: 1 to 25 HP (B-104)
- ☐ Laboratory and small-batch production types (B-112)
- ☐ Condensed catalog showing all types (B-109)
- ☐ Quick-change rotary mechanical seals for pressure and vacuum mixing (B-111)
- ☐ Data sheet for figuring mixer requirements (B-107)

Check, clip, and mail with your name, title, company address to:

MIXING EQUIPMENT Co., Inc., 199-c Mt. Read Blvd., Rochester 11, N.Y.

In Canada: Greey Mixing Equipment, Ltd., 100 Miranda Ave., Toronto 10, Ont.